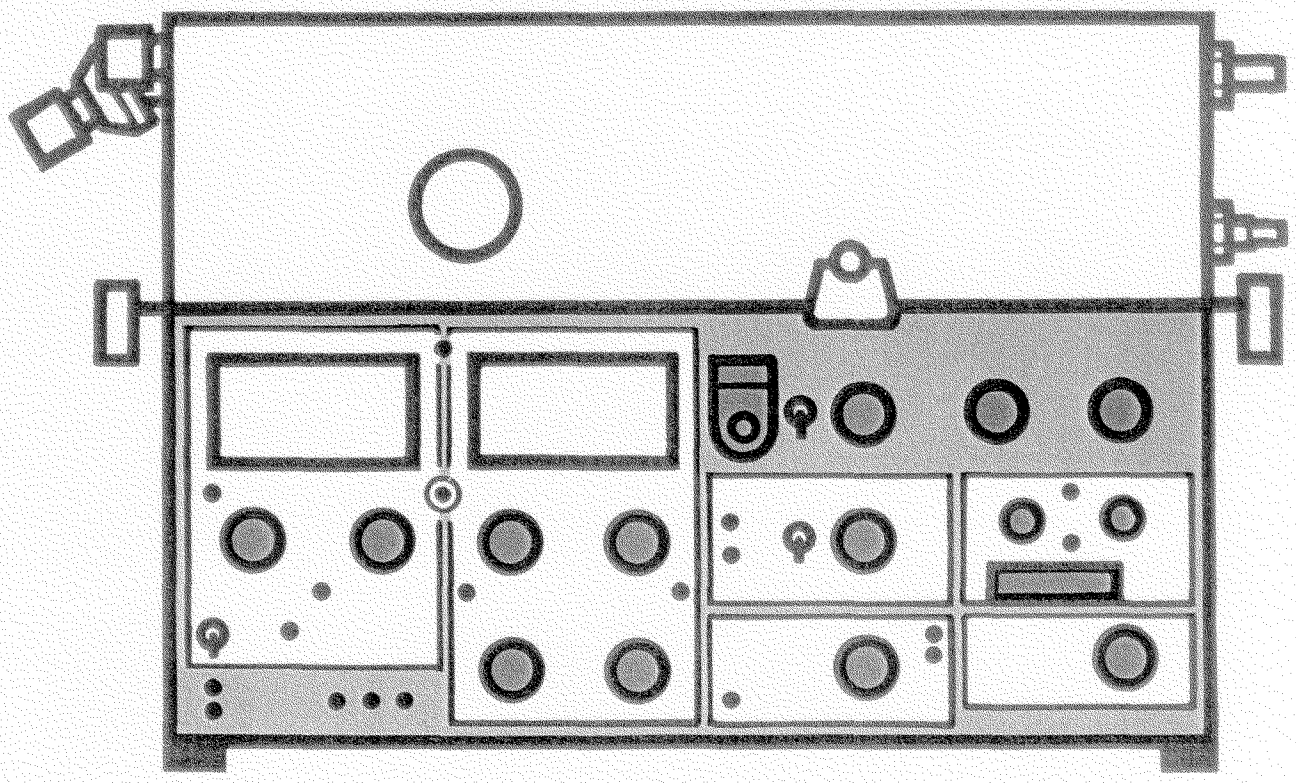
SIEMENS

Servo Ventilator 900 C/D/E

Service Manual



Life Support Systems

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All parts in the Servo Ventilator are comprised by a spare part exchange system.

Your local Siemens representative supplies factory calibrated and tested plug-in circuit boards as well as other spare parts indicated in the spare parts list. When exchanging spare parts, always state serial number of the apparatus and fault-symptom.

Note that the Operating Manual is an indispensable complement to the Service Manual for proper servicing.

NOTE. For the service work on the Servo Ventilator, we recommend the use of Siemens-Elema Service Case.

To the responsible service personnel

The contents of this document are not binding. If any significant difference is found between the product and this document, please contact Siemens for further information.

We reserve the right to modify products without amending this document or advising the user.

We recommend using authorized Siemens personnel for all service and repairs and the use of Siemens-Elema exchange parts or genuine spare parts. Siemens will not otherwise assume responsibility for the materials used, the work performed or any possible consequences of same.

About this manual

This Service Manual is intended for Servo Ventilator 900 C, D and E.
When reading the manual, please note:

SV 900 C

Read all information

SV 900 D

Do not read information outlined in red

SV 900 E

Do not read information in shaded areas

Product information program

This Service Manual is a part of a comprehensive information program for Servo Ventilator 900 C/D/E. The program is planned to contain the following:

Promotional and Scientific Publications

Brochure	Servo Ventilator Concept	Application Brochures: Intensive Care, Anesthesia, Transportation	Product Leaflet	Reprints

Operating and Service Instructions

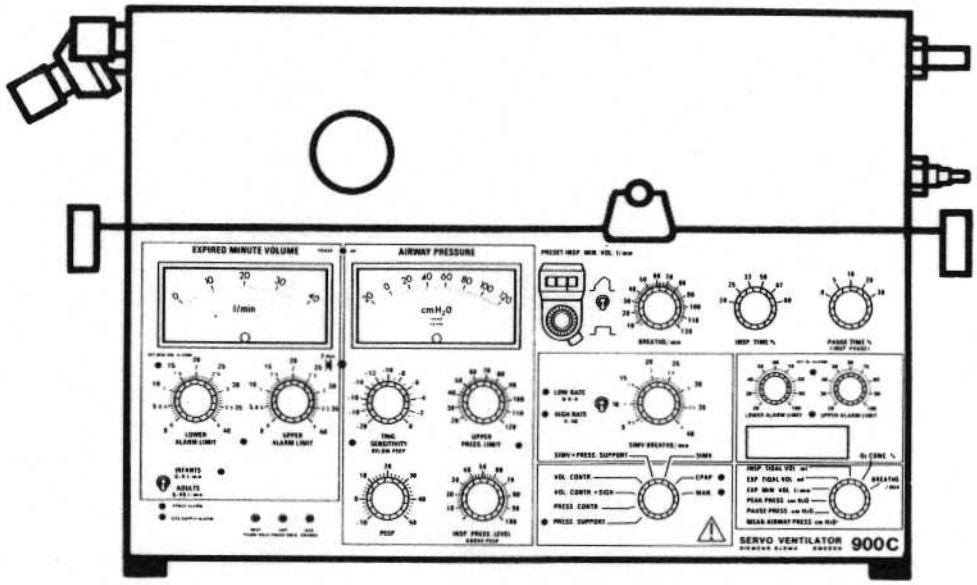
Operating Manual	Brief Operating Instructions	Wall Diagram for Cleaning	Service Manual	Circuit Diagram

Product Training Material

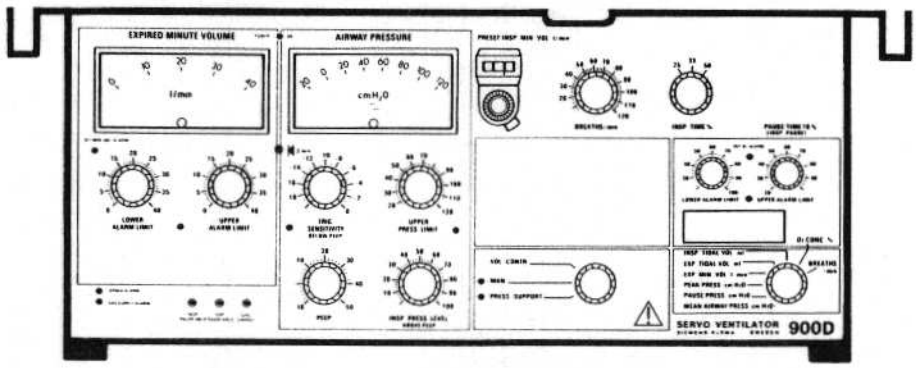
Training Instructions	Advisory Booklet for Instructors	Slide Series including Textbook	"I am breathing through a ventilator" Film and Booklet	The Patient's ABSee® Cards and Poster
Front Panel — Flip-chart	Panel Block	Trainee's Set	Video programs, Video guide, Video news	

Introduction

Pneumatic unit

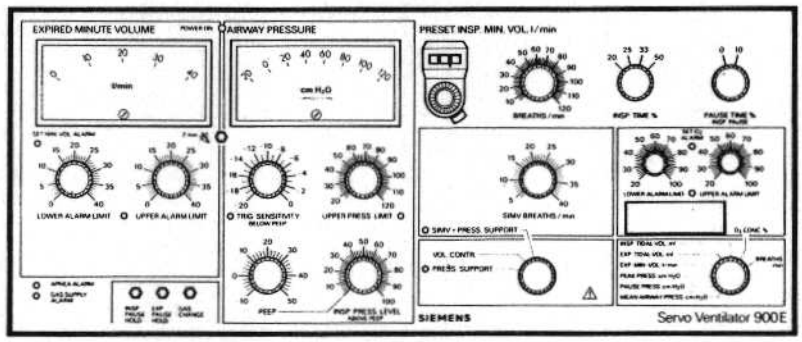


Electronic unit SV 900 C



Electronic unit SV 900 D

Electronic unit SV 900 E



Principle of operation

The Servo Ventilator 900 C/D/E consists of two separate units.

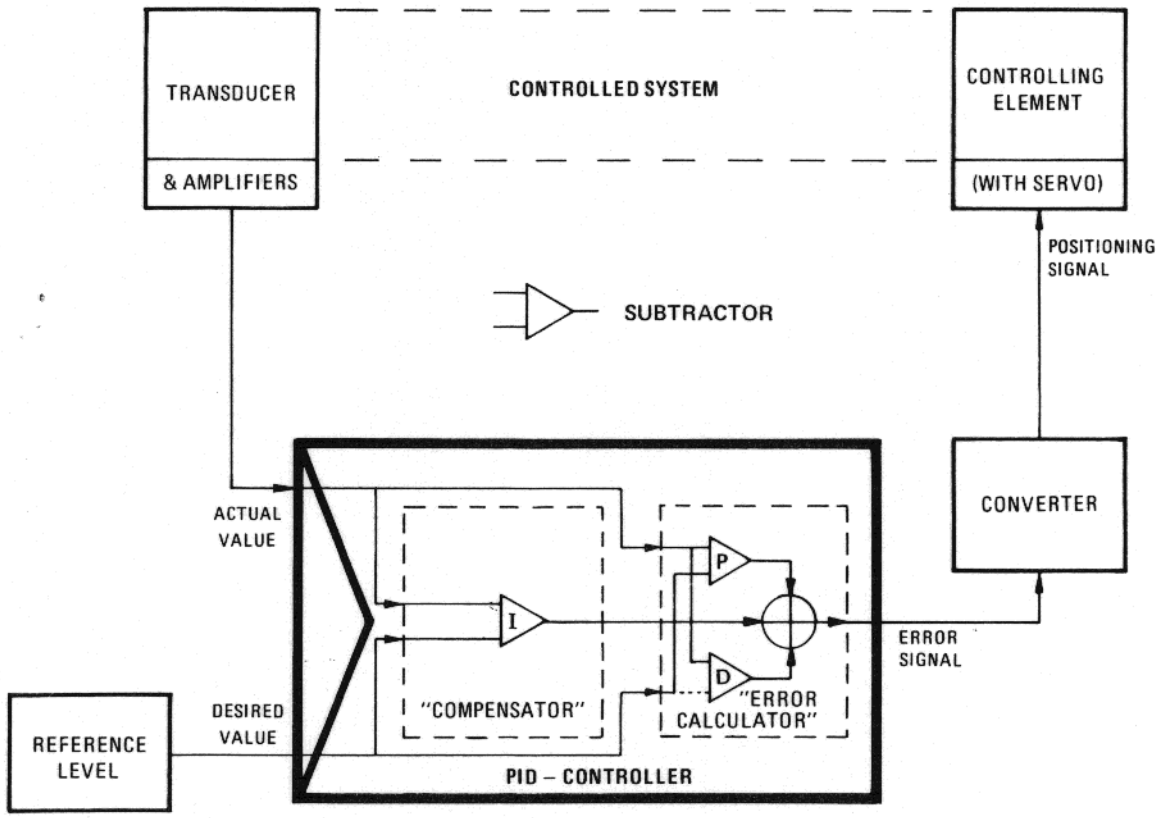
The pneumatic unit comprises the gas conduction system with two pressure transducers, two flow transducers and two servo valves.

Each transducer, continuously delivers its actual value to the electronic unit.

The servo valves are used as CONTROLLING ELEMENTS for the control of inspiratory and expiratory gas conduction.

The electronic unit comprises three controlling systems, two for regulation of inspiration and one for regulation of expiration.

The three controlling systems will be in use, one at a time, depending on the TIMING control and the selected ventilation MODE.



Feedback control (= regulation system)

Each of the controlling systems comprises its PID-controller, (P=Proportional action, I=Integral action and D=Derivative action), as shown in the picture.

The CONTROLLING ELEMENT will be positioned by the PID-CONTROLLER (output).

P-action gives a continuous basic positioning. (Thereby the ACTUAL VALUE will correspond to the DESIRED VALUE).

I-action gives a slowly varying positioning compensation for small long time error (in the ACTUAL VALUE).

D-action gives a speed-up positioning reaction at fast changes (in the ACTUAL VALUE).

The actual value from the TRANSDUCER in use is compared with the desired value from REFERENCE LEVEL. The difference between the ACTUAL VALUE and the DESIRED VALUE results in an ERROR SIGNAL, which is converted to a positioning signal for the CONTROLLING ELEMENT (inspiratory and expiratory valve respectively). The valve in use will then be moved into such a position that the error will be corrected. In this way, the desired value is maintained independently of changes in the airways and the lungs.

Principle diagram

❶ Reference level

The main block REFERENCE LEVEL generates the DESIRED VALUE for each regulating system, corresponding to the settings on the front panel.

❷ Regulation of inspiration

The regulation of inspiration is done by means of the FLOW SERVO LOOP in the following modes: VOL. CONTR., VOL. CONTR.+SIGH, MAN., each mandatory inspiration during SIMV+PRESS. SUPPORT and each mandatory inspiration during SIMV.

The actual value for the controller in this loop comes from the FLOW TRANSDUCER in the inspiratory channel.

The regulation of inspiration is done by means of the PRESSURE SERVO LOOP in the following modes: PRESS.SUPPORT, PRESS.CONTR., CPAP, each spontaneous inspiration during SIMV+PRESS.SUPPORT and each spontaneous inspiration during SIMV.

The actual value for the controller in this loop comes from the PRESSURE TRANSDUCER in the inspiratory channel.

The ERROR SIGNAL from the controller in use (flow or pressure), is fed to a converter, common to both inspiratory servo loops, which delivers the valve control signal to the inspiratory valve (positioning).

For both servo loops, the inspiratory valve is the controlling element in regulation of inspiration.

❸ Timing

Reference timing pulses (START SIMV CYCLE, CLOCK, INSP.TIME and EXP.TIME) are generated in this main block.

The TIMING gets some command variables from the front panel settings.

❹ Monitoring

The monitoring of all values that are displayed on the panel meters and the digital display takes place in this main block.

Some of the readings are compared with preset alarm limits and visual and audible alarms are activated if the preset limits are exceeded.

The monitoring system is independent of the regulating systems.

The pressure limiting system is included in this main block.

❺ Regulation of expiration

The regulation of expiration is done by means of the PRESSURE SERVO LOOP during expiration in all modes when using PEEP.

The actual value for the controller in this loop comes from the PRESSURE TRANSDUCER in the expiratory channel.

The error signal from the controller is fed to a converter which delivers the valve control signals for the expiratory valve (positioning).

The expiratory valve is the controlling element in regulation of expiration.

❻ Power supply

The four regulated supply voltages are; +5V, ±15V and +24V.

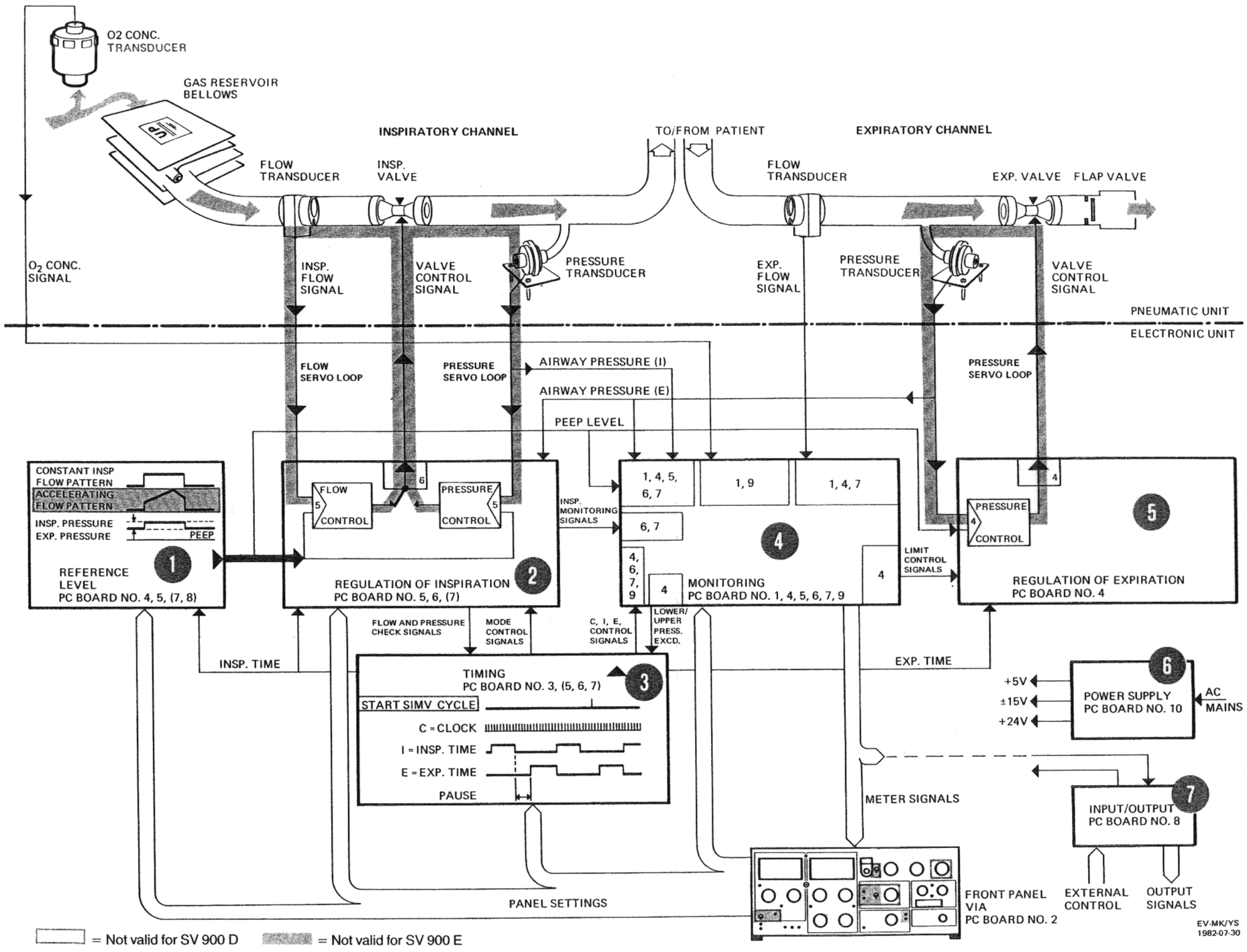
❼ Input/output

Output signals are buffered in this main block.

Some of the functions of the ventilator can be externally controlled via inputs in this block.

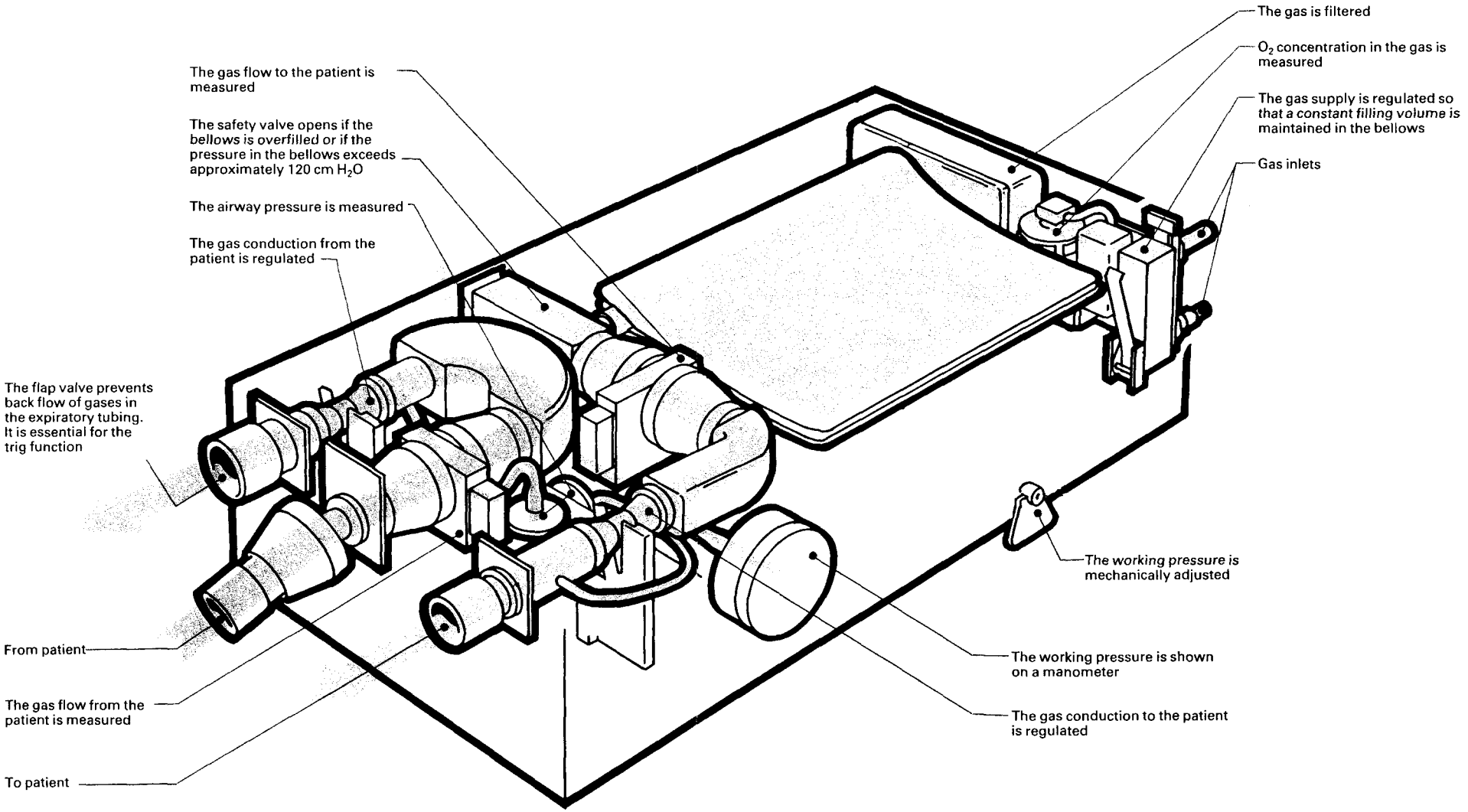
□ = Not valid for SV 900 D ▒ = Not valid for SV 900 E

Principle diagram



Pneumatic unit

Gas flow through the ventilator


The gas is filtered
O_2 concentration in the gas is measured
The gas supply is regulated so that a constant filling volume is maintained in the bellows
Gas inlets
The gas flow to the patient is measured
The safety valve opens if the bellows is overfilled or if the pressure in the bellows exceeds approximately 120 cm H_2O
The airway pressure is measured
The gas conduction from the patient is regulated
The flap valve prevents back flow of gases in the expiratory tubing. It is essential for the trig function
The working pressure is mechanically adjusted
From patient
The working pressure is shown on a manometer
The gas flow from the patient is measured
The gas conduction to the patient is regulated
To patient

A more detailed description of the pneumatic unit is found in the Training Instructions

Gas supply

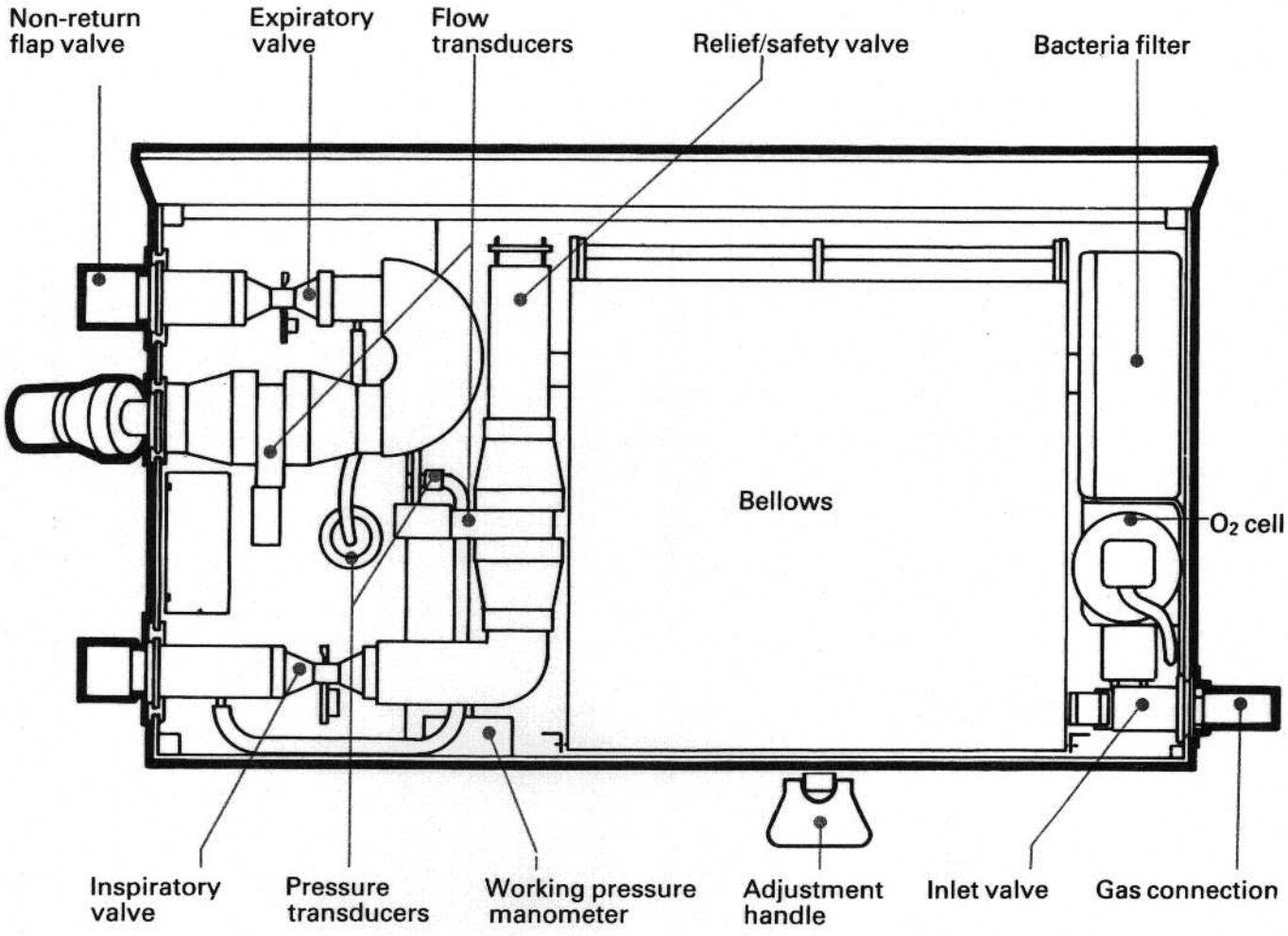
The lower gas inlet is used for high pressure gases 250–700 kPa). The inlet can be connected either via Siemens-Elema gas mixer or directly to the hospital central gas supply, to gas bottles or to a compressor.

The upper gas inlet is used for low pressure gases, e.g. from an anesthesia circuit or a flowmeter. Normally, only one of the two inlets is used at a time.

In any case, the gases pass a one-way valve, an O_2 cell and a bacteria filter. The bacteria filter removes 99.998% of all particles down to a size of 0.3 microns.

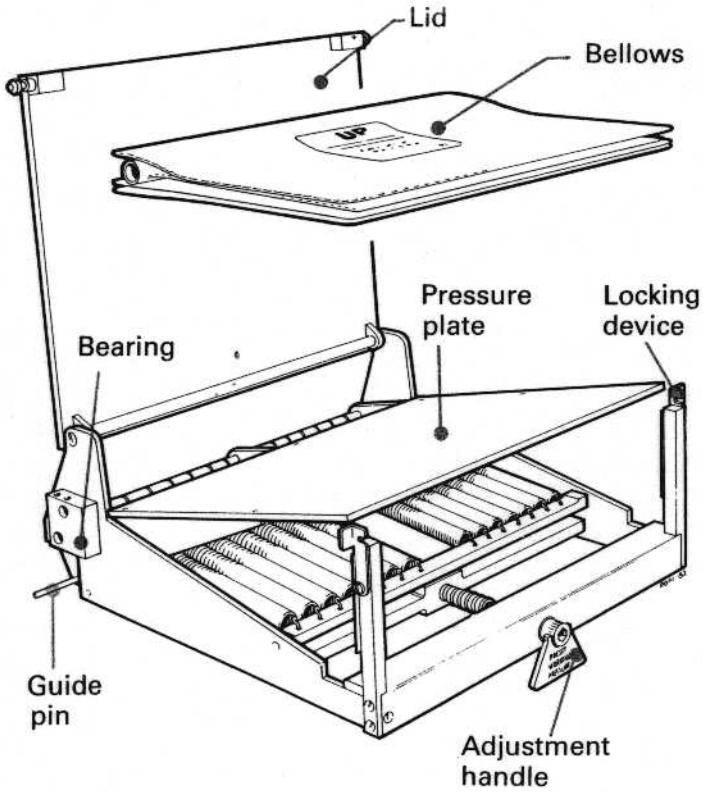
When an anesthesia vaporizer is used, the gas supply unit has a different construction with three nipples. For further information, see the Operating Manual for the vaporizers.

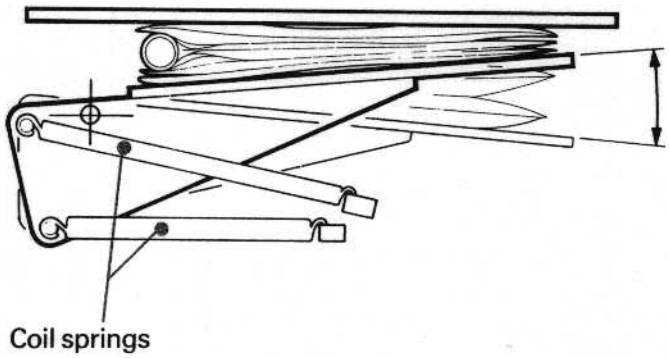
When the gas is supplied via the high pressure inlet, a constant filling volume is obtained in the bellows by means of the gas inlet regulatory function of a controlled inlet valve. A constant working pressure is obtained by the action of the spring assembly.



Bellows and spring assembly

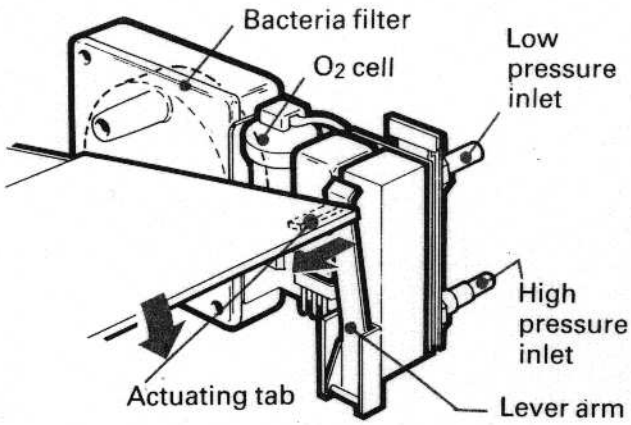
The bellows are placed in a double coil spring set between two metal plates. The lower plate is movable and spring tensioned. The upper plate acts as a lid, which is firmly positioned above the bellows.



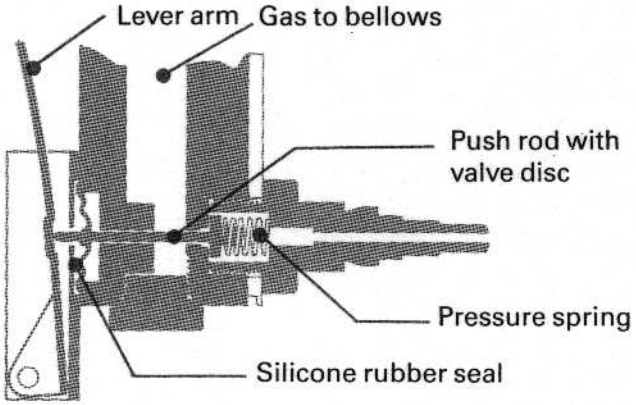


A double coil spring set is arranged to give a constant pressure to the bellows, independent of the plate position. The pressure is set by the adjustment handle PRESET WORKING PRESSURE.

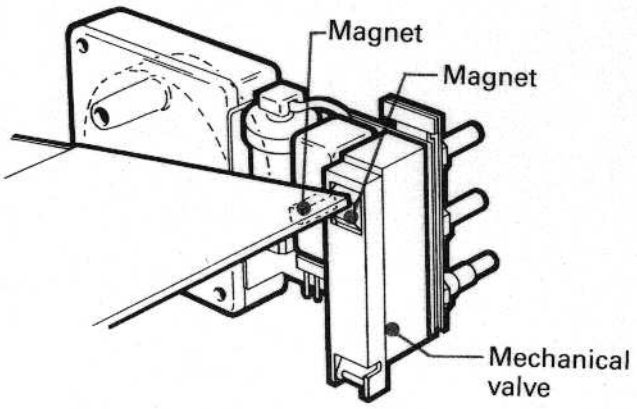
Gas supply unit (mechanically actuated)



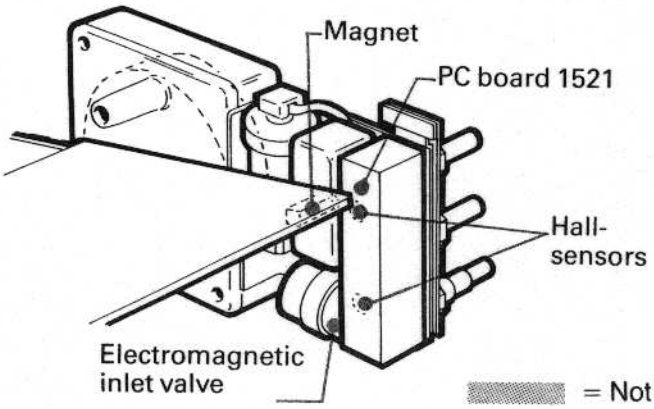
Controlled inlet valve (mecanical valve)



Gas supply unit with magnets



Electronic gas supply unit



Gas supply unit

The gas supply unit contains an on-demand valve for the high pressure gas, a controlled inlet valve, two one-way valves, the O_2 cell holder and a bacteria filter.

Normally, the high pressure inlet is used and the bellows are filled through the controlled inlet valve, a one-way valve and the bacteria filter.

Mechanically actuated gas supply unit

The pressure plate acts upon the controlled inlet valve via the lever arm. Before connecting the gas supply, the bellows are empty, the pressure plate in top position and the controlled inlet valve open. When connecting high pressure gas, the bellows fills, the actuating tab on the right edge of the pressure plate goes down against the lever arm until the controlled inlet valve has closed. The pressure plate is then in its regulating position, which means that during inspiration, gas is continuously fed to the bellows. Thus a constant gas volume is kept in the bellows when using the high pressure inlet.

When a constant gas flow (from a flowmeter) is supplied via the low pressure inlet, excess gas will be let out from the bellows by the relief valve (surplus function).

Gas supply unit for vaporizer with magnets

When using vaporizer, type Siemens-Elema 950, 951 or 952, a gas supply unit with three gas inlets has to be used and the actuating tab on the pressure plate must be replaced by a magnet kit.

Electronic gas supply unit for vaporizer

The gas is normally supplied via a gas mixer at the lower gas inlet. This inlet is controlled by a 24 V electromagnetic inlet valve.

The built-in PC-board has two Hall-sensors, sensing the position of the pressure plate magnet. When the magnet reaches up to the upper Hall-sensor, the inlet valve will open. When the magnet reaches down to the lower Hall-sensor, the inlet valve will close.

Also when there is no power, the inlet valve is kept closed.

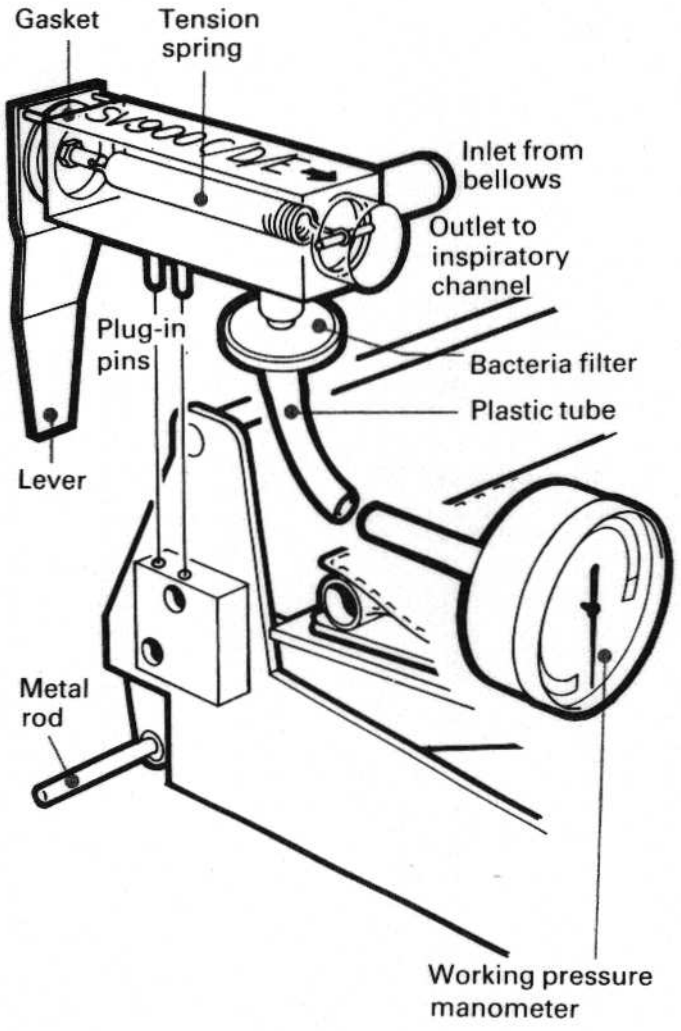
= Not valid for SV 900 E

O_2 cell

The O_2 cell used in the ventilator gives an output voltage proportional to the partial pressure of O_2 at the cell. At constant sum of barometric pressure and WORKING PRESSURE (and constant temperature), the output voltage is proportional to the relative O_2 CONCENTRATION.

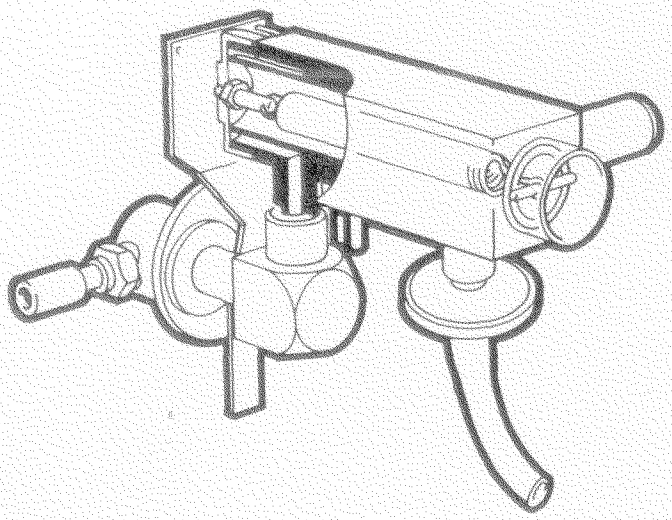
For each O_2 cell, the variable output will stay at a fairly constant level during the life time of the cell (approximately 800 000 %xhours).

The output voltage level from the cell is usually within 7–15 mV in normal air.



Relief/safety valve and working pressure manometer

The working pressure manometer is connected to the safety valve via a plastic tube. A bacteria filter protects the manometer from contamination.



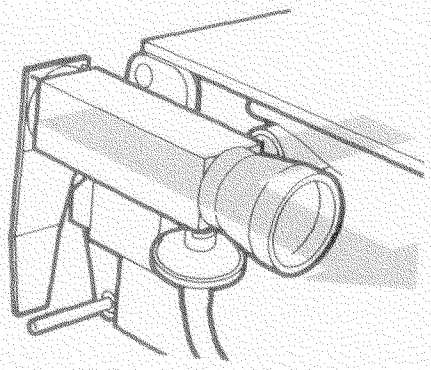
Relief/safety valve for gas evacuation

A special relief/safety valve has to be used for gas evacuation.

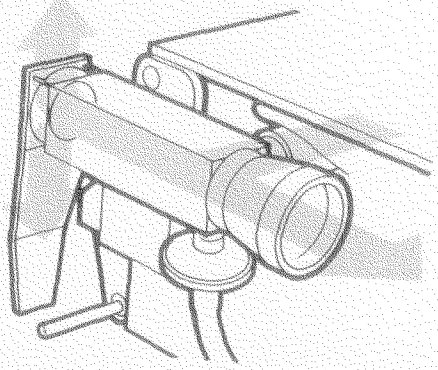
For details, see corresponding Operating Manual.

The relief/safety valve may be opened in two ways. Firstly, if the bellows tend to overfill, a metal rod will push the lever to let out excess volume (surplus function). Secondly, if the working pressure exceeds approximately 120 cm H_2O, the valve will let out excess pressure (safety function).

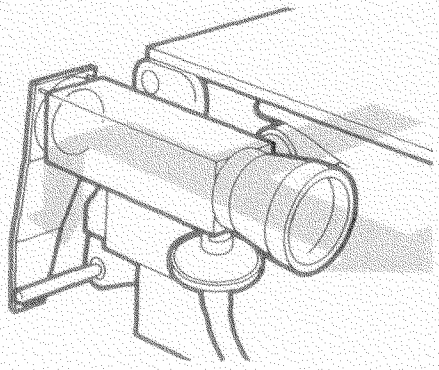
Normal function



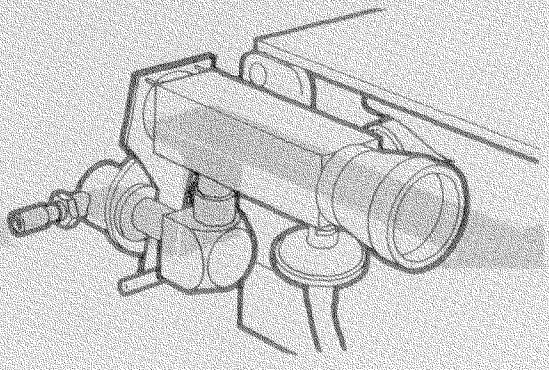
Safety function



Surplus function



Surplus/safety function when using gas evacuation system



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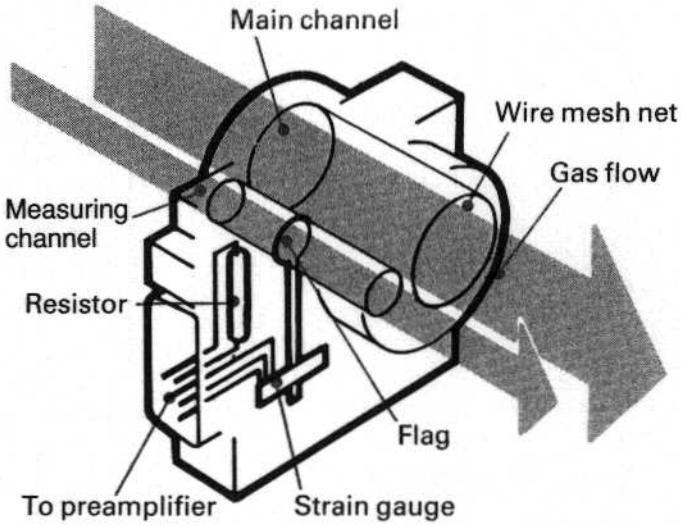


Flow transducer

The inspiratory and expiratory flow transducers have the same construction. The gas flows through the flow transducer in two parallel channels, one large main channel, and one small measuring channel.

The main channel is fitted with a wire mesh net, the resistance of which causes a certain proportion of the gas to flow through the measuring channel.

The flow through, and the differential pressure across, the measuring channel acts on a small metal disc ("flag"), which, via a metal pin presses on a small semiconductor strain gauge. This consists of diffused resistors on both sides of an elastic silicone rod. The resistors are connected as a part of a Wheatstone bridge, the other part of which is situated on the TRANSDUCER INTERFACE board (PC 765).

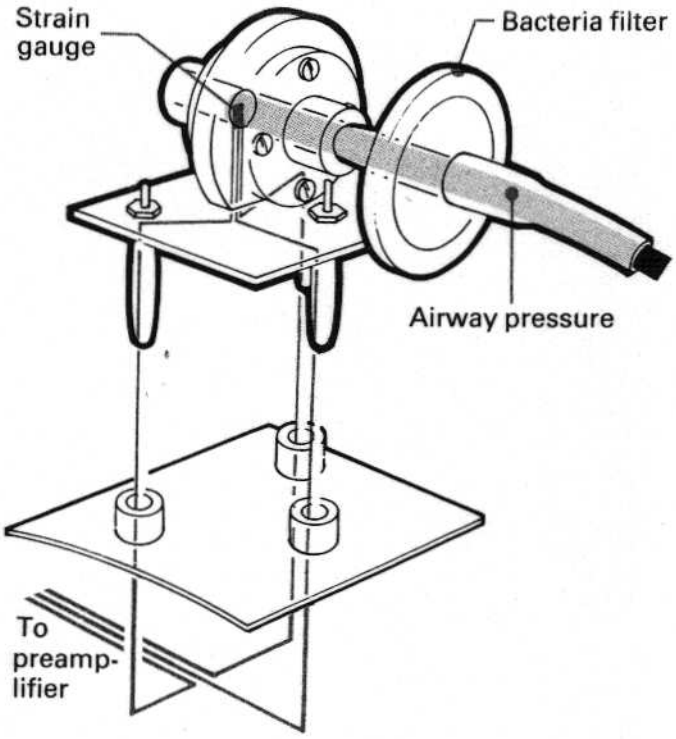
The more flow in the channel, the higher the pressure on the strain gauge. The change in resistance in the Wheatstone bridge, is converted to a corresponding signal voltage.

The output signal from the flow preamplifier is a non-linear function of the flow. The flow preamplifier signals are linearized on PC board 5 (inspiration) and on PC board 4 (expiration), respectively.

A resistor, 220 Ohms, 6W, is moulded into the transducer and is used for heating of the expiratory flow transducer. The transducer is heated to approximately 60°C (140°F) to prevent condensation of water vapour. The inspiratory flow transducer has the same resistor, but since it is not connected to any voltage, it will not be heated.

If water should condense in the expiratory flow transducer, the resistance of the wire mesh net increases. Thus the output signal will increase. This can be seen on the meter EXPIRED MINUTE VOLUME, or on the digital display, as an increased reading. The accumulation of medicaments, mucus and secretions in the expiratory flow transducer gives the same result.

For details on cleaning and calibration of the flow transducer, see the chapters Routine cleaning and Calibration in the Operating Manual.



Pressure transducer

The pressure transducers in the inspiratory and expiratory channels are of the same type.

The gas pressure acts upon a silicone rubber membrane into which is moulded a strain gauge of the same type as in the flow transducers. The strain gauge resistors are connected as a part of a Wheatstone bridge, the other part of which is situated on the TRANSDUCER INTERFACE board (PC 765).

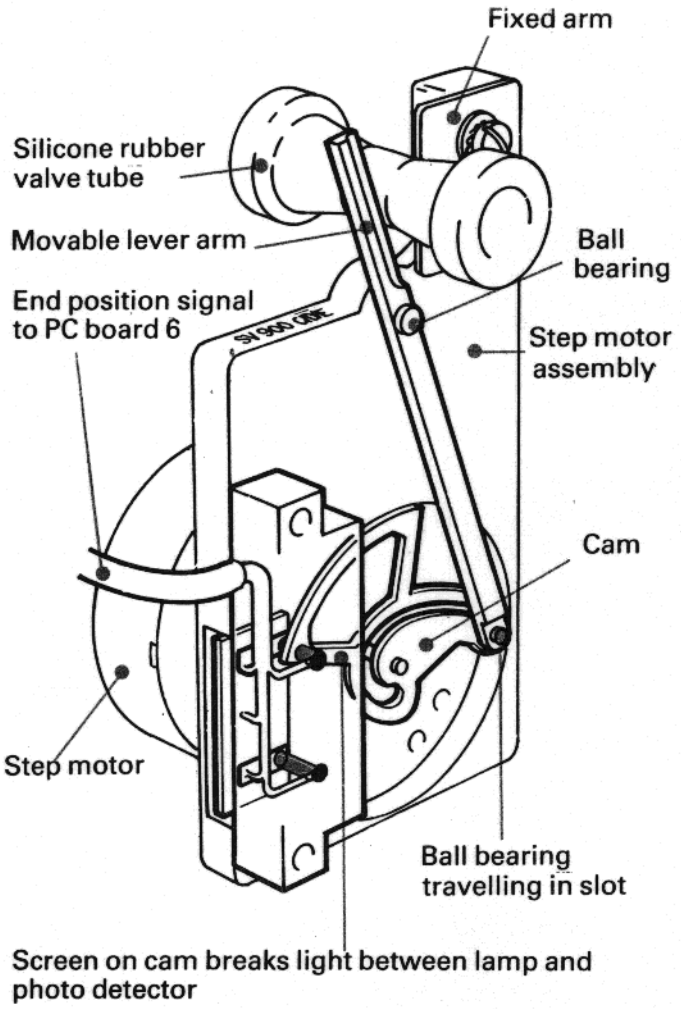
The output signal voltage from the pressure amplifier is proportional to the gas pressure.

When replacing the pressure transducers, the preamplifier zero and gain have to be adjusted. For details, see the chapter Calibration in the Operating Manual.

Each pressure transducer is connected to its channel via a plastic tube and a bacteria filter. The bacteria filter and the plastic tube for the inspiratory channel should be replaced after every 1000 hours of operation.

The bacteria filter and the plastic tube for the expiratory channel should be replaced after every patient.

Inspiratory valve and step motor



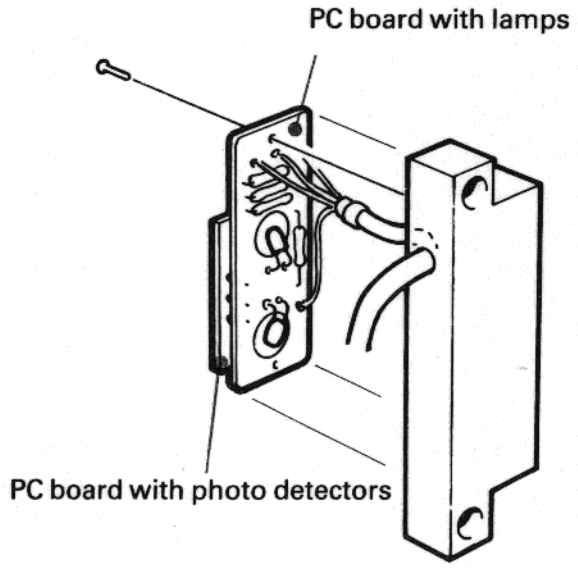
The inspiratory valve is operated by the step motor via the logarithmically slotted cam and the lever arm.

When the step motor is in operation, a ball bearing at the end of the lever arm travels in the slot. The lever arm squeezes the inspiratory valve tube against a fixed arm. The change in the flow is approximately 10% for each step of the step motor, independent of the motor position as long as the airway pressure is unchanged.

The step motor has four coils which are fed with positioning signals from PC board 6 in the electronic unit.

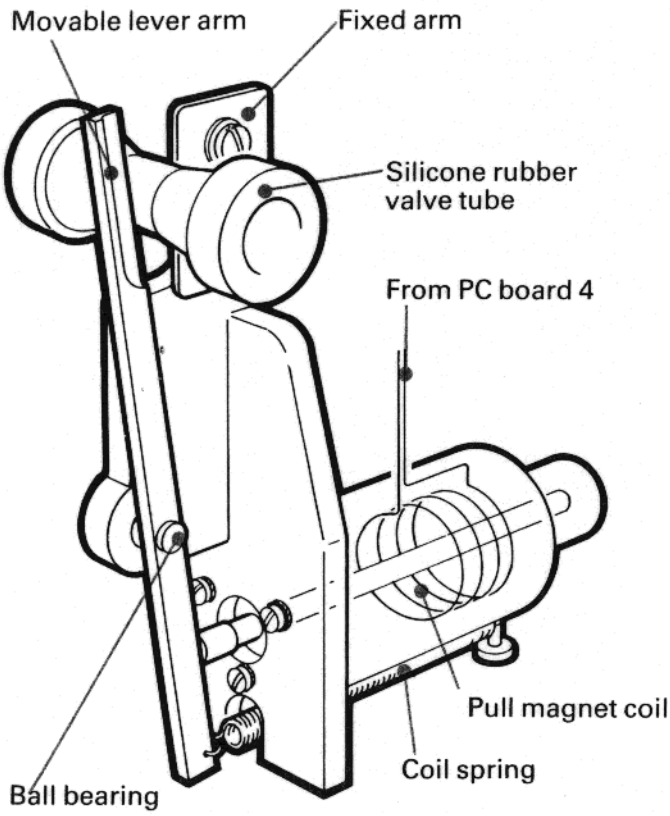
When the mains voltage is switched off (or at mains voltage failure) the step motor will always end up with the inspiratory valve in fully opened position.

The maximum speed of the step motor is about 480 steps/second and the time elapsing from fully open to fully closed position is approximately 0.1 second.



The plastic case contains two PC boards, one with two miniature lamps and the other with two photo detectors. When the step motor reaches either end position of the cam slot, the light beam between the lamp and the photo detector is interrupted by the cam screen. This will generate an end position signal for the electronic circuits on PC board 6.

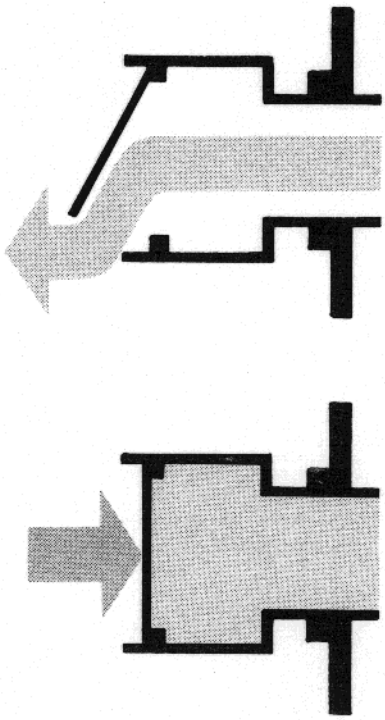
The position of the lamps in relation to the screen is of the utmost importance. If the lamps by any chance come out of position, this will cause the step motor to "rattle" because end positions are not properly indicated. The same symptom occurs if a lamp is damaged.



Expiratory valve and pull magnet

The expiratory valve comprises a pull magnet acting on a lever arm which squeezes a silicone rubber valve tube against a fixed arm. The valve will close when the magnet is activated. When the supply current to the magnet is removed, the valve will open fully because of the spring. This ensures that the patient can always exhale through the ventilator at voltage failure.

The expiratory valve is controlled by the signals from the electronic unit. At a PEEP setting, the information from the pressure transducer in the expiratory channel regulates the valve position during expiration.

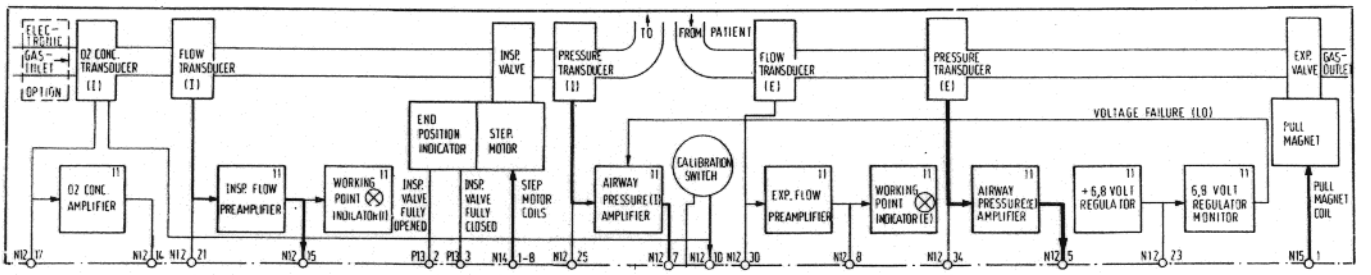


Non-return valve

The purpose of the flap valve is to prevent air from entering the patient circuit through the expiratory channel.

The valve is a vital part of the triggering function since a patient trig is sensed in the expiratory channel (pressure drop).

Transducer interface (PC board no 11)



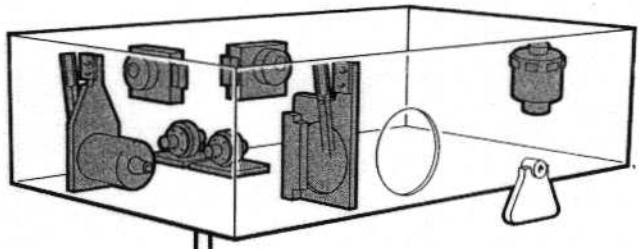
This PC board comprises the preamplifiers for INSP. FLOW and EXP. FLOW, the amplifiers for AIRWAY PRESSURE (I), AIRWAY PRESSURE (E) and O_2 CONCENTRATION.

The INSP.FLOW WORKING POINT INDICATOR, EXP.FLOW WORKING POINT INDICATOR and the 6.8V REGULATOR and its 6.8V REGULATOR MONITOR are also included on this PC board.

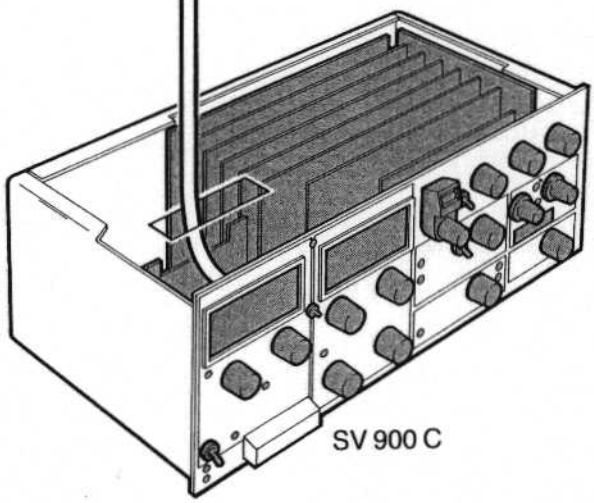
The CALIBRATION POTENTIOMETERS and the CALIBRATION SWITCH are situated on this PC board.

On failure in the 6.8V REGULATOR indicated by the 6.8V REGULATOR MONITOR block, the block AIRWAY PRESSURE (I) AMPLIFIER will be influenced to generate a high AIRWAY PRESSURE (I) signal which will result in UPPER PRESSURE ALARM condition.

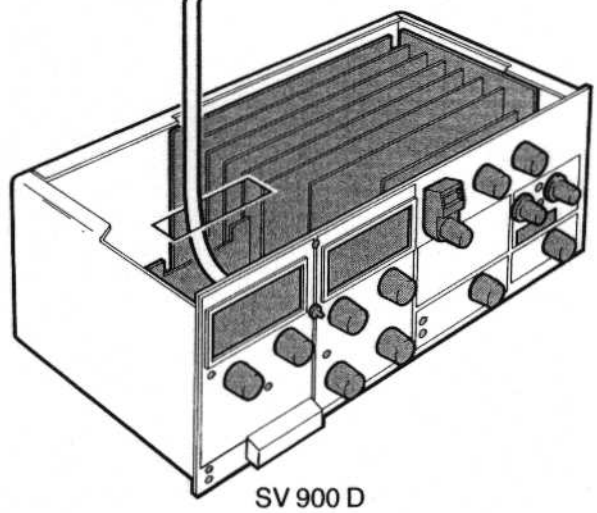
Electronic unit – Principle of operation



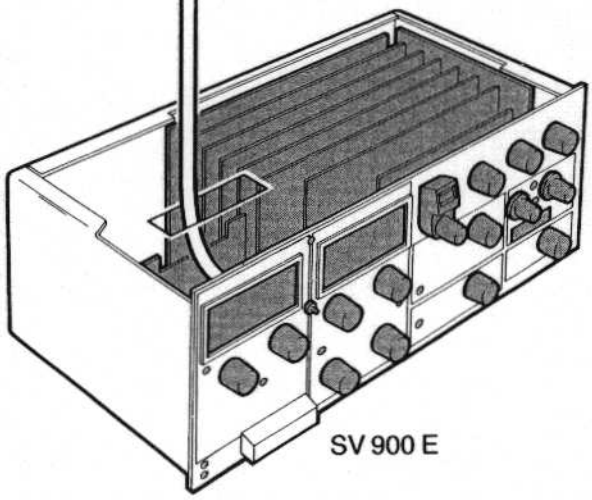
The electronic unit contains the various electronic circuits for regulation and monitoring. A general description is found in chapter Introduction and the following chapter comprises a detailed description of the PC boards included in the electronic unit.



SV 900 C

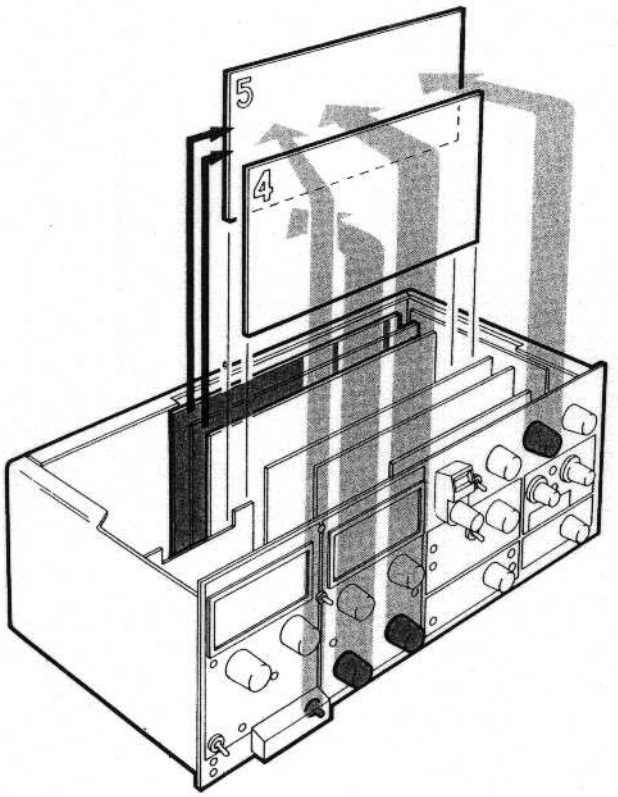


SV 900 D



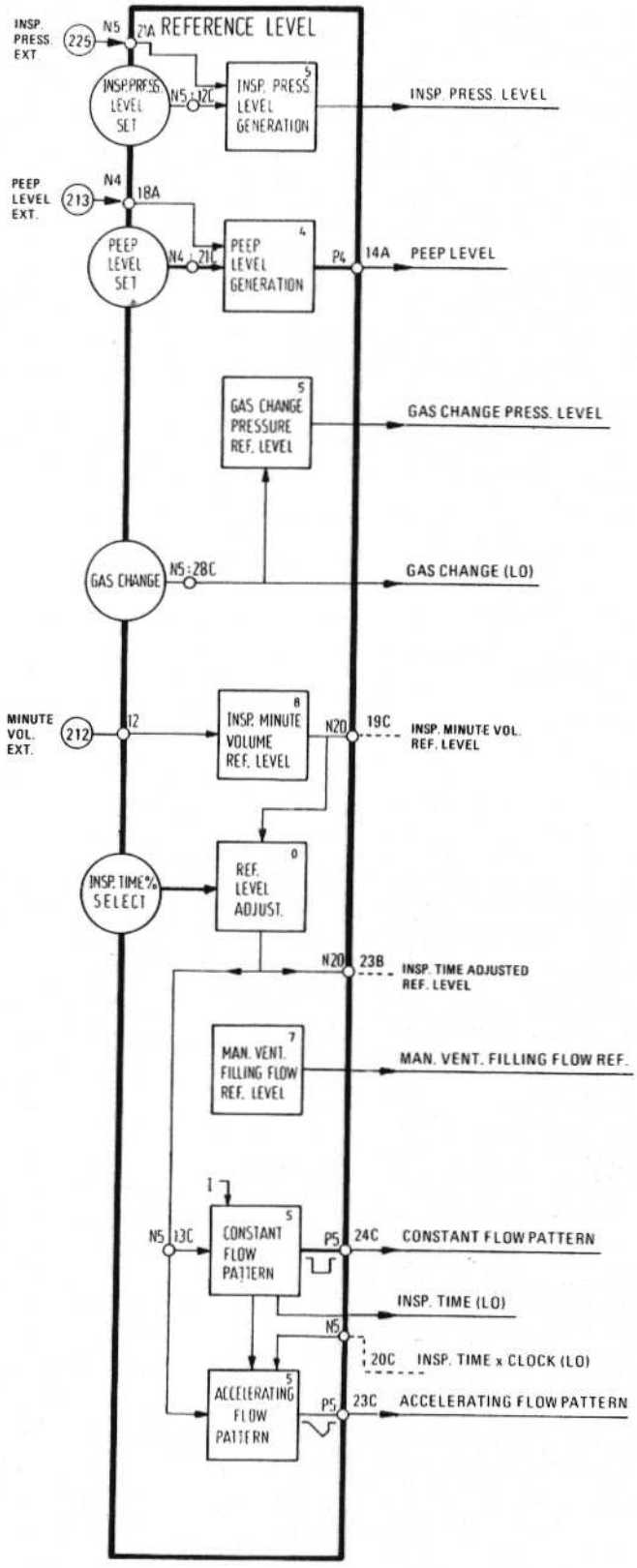
SV 900 E

Electronic unit – Reference level generation



General

The front panel settings are converted to reference level signals for the regulating systems.



Description of block diagram

The text also refers to the circuit diagrams.

Insp. press. level generation (PC board no 5)

The input signal is the command value INSP. PRESSURE LEVEL SET (0–2.5V) from the front panel knob INSP. PRESS. LEVEL ABOVE PEEP (0–100 cm H_2O). The command value can be overruled by an input voltage (0–2.5V) supplied to the rear panel CONTROL TERMINAL (N28:25), INSP. PRESS. EXTERNAL

The output (V21:8) represents the INSP. PRESS. LEVEL ABOVE PEEP (0–100 cm H_2O).

Peep level generation (PC board no 4)

The input signal is the command value PEEP LEVEL SET (0–2.5V) from the front panel knob PEEP (–10 — +50 cm H_2O). The command value can be overruled by an input voltage (0–2.5V) supplied to the rear panel CONTROL TERMINAL (N28:13), PEEP LEVEL EXTERNAL.

The output (V6:8) represents the value PEEP LEVEL (–10 — + 50 cm H_2O).

Gas change pressure ref. level (PC board no 5)

The input signal GAS CHANGE (LO) comes from the front panel pushbutton GAS CHANGE:

As long as the pushbutton is depressed a reference value (V17:8 via V2), corresponding to a constant inspiratory pressure level (+20 cm H_2O), will be fed to the block INSP. PRESSURE REF. LEVEL (V18:3).

Insp. minute volume ref. level (PC board no 8)

This block is used for generation of a reference level.

The normally (+5V), constant output value INSP. MINUTE VOLUME REF. LEVEL, can be externally influenced when applying a voltage of –5 to +5 V at the rear panel CONTROL TERMINAL (N28:12), MINUTE VOLUME EXTERNAL.

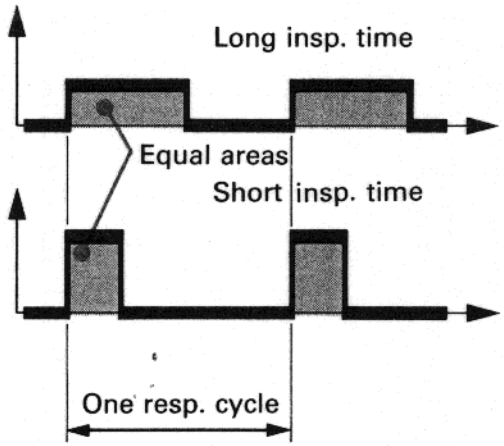
Man. vent. filling flow ref. level (PC board no 7)

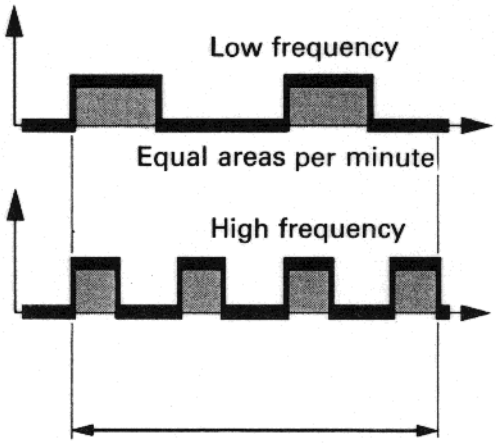
This block consists of the resistors R14 – R16, setting the constant MAN. VENT. FILLING FLOW REFERENCE (+1.15 V) for the filling flow to the breathing bag during manual ventilation. During MAN mode this is used as the desired INSP. FLOW value for the filling flow to the manual breathing bag. The resulting momentary filling flow value is equal to 3 × PRESET INSP. MINUTE VOLUME (front panel setting).

Example: PRESET INSP. MINUTE VOLUME set at 6 l/min gives a filling flow of 3 × 6 l/min = 18 l/min = 0.3 l/s.

= Not valid for SV 900 E

Electronic unit – Reference level generation





Ref. level adjust (front panel; INSP. TIME % selector)

In this block, the constant (normally +5V) value from INSP. MINUTE VOLUME REF. LEVEL is converted into INSP. TIME ADJUSTED REFERENCE LEVEL by the voltage divider on the front panel selector.

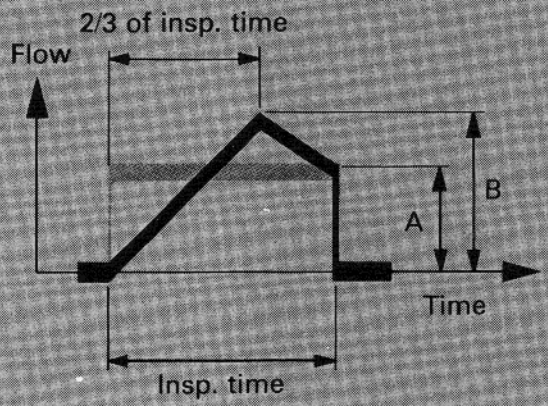
The square wave reference signal as well as the accelerating flow reference signal is inversly proportional to the preset INSP. TIME %, since a constant tidal volume (area) should be maintained regardless of the setting of the INSP. TIME % front panel knob. See diagram.

If the set respiratory rate increases, the tidal volumes decreases, so that a constant minute volume is maintained regardless of the respiratory rate. See diagram.

Constant flow pattern (PC board no 5)

Inputs are INSP. TIME ADJUSTED REFERENCE LEVEL and the digital control signal INSP. TIME.

The output, (V23:8), is the reference value (negative) used in the block ACCELERATING FLOW PATTERN and during INSP. TIME as a reference value (V31) CONSTANT FLOW PATTERN to the INSP. FLOW ERROR CALCULATOR and to the VOLUME COMPENSATOR.



Accelerating flow pattern (PC board no 5)

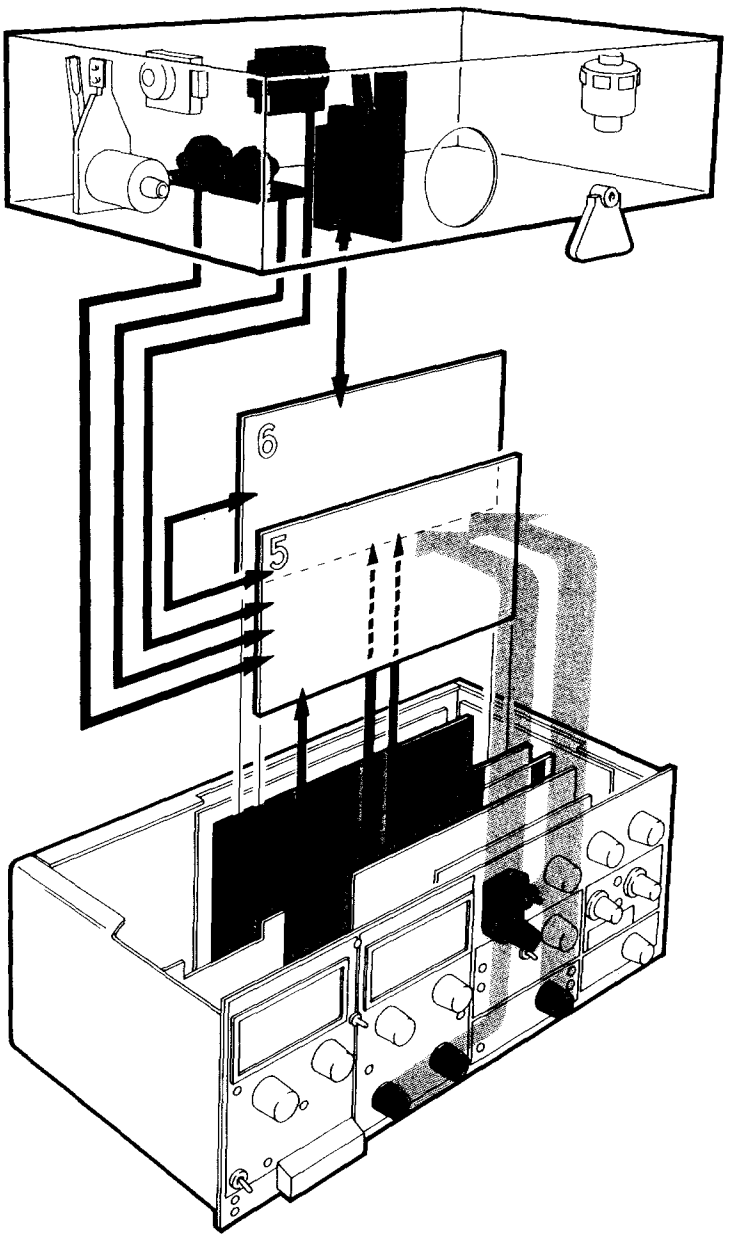
The reference signal (V23:1) ACCELERATING FLOW PATTERN is generated during INSP. TIME.

The accelerating flow pattern reference signal rises with a constant slope (staircase generator) during the first two thirds of the inspiration time. During the remainder of the inspiration time, the reference signal decreases. See the diagram, in which the corresponding CONSTANT FLOW PATTERN reference signal is also indicated.

The maximum amplitude (B) of the accelerating flow signal is approximately 50% higher than the amplitude (A) of the square-wave shaped signal. NOTE! Both on the front panel and in the diagrams, the square-wave shaped flow reference signal and the accelerating flow reference signal are represented as positive-going signals. In reality, these signals are negative-going.

= Not valid for SV 900 D = Not valid for SV 900 E

Electronic unit – Regulation of inspiration

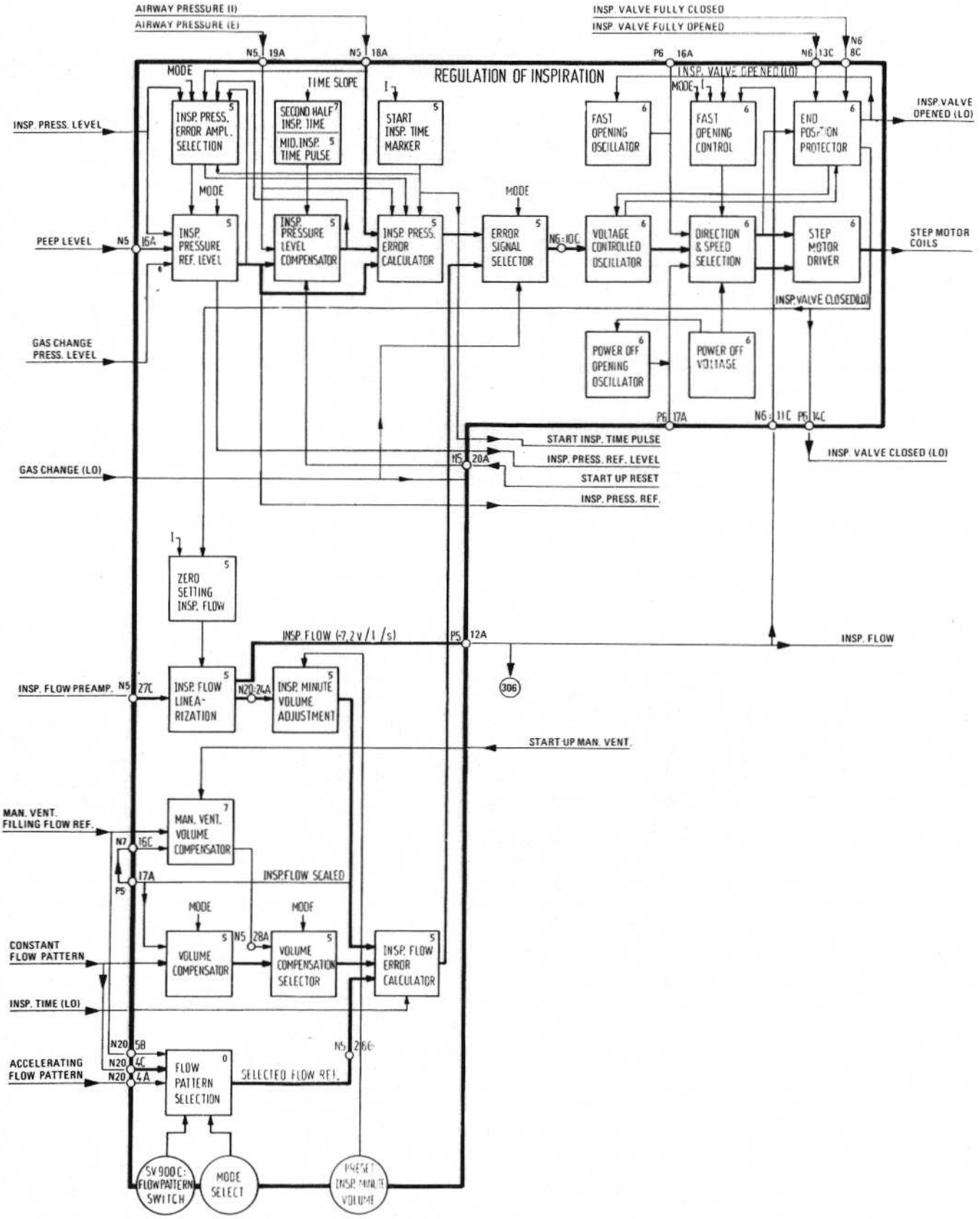


General

The regulation of inspiration is done by means of the FLOW or PRESSURE SERVO LOOP depending on selected mode.

The actual values for the controllers in these loops come either from the inspiratory flow transducer or the pressure transducers.

Electronic unit – Regulation of inspiration



Description of block diagram

The text also refers to circuit diagrams

Insp.flow linearization (PC board no 5)

The signal INSP. FLOW PREAMPLIFIER, is a non-linear function of the flow in the inspiratory channel. The signal is linearized in this block.

The linearized output signal (V22:8), represents a linear measure of the momentary flow in the inspiratory channel.

INSP. FLOW is also fed to the 15-pole connector for auxiliary equipment at the rear panel.

Zero-setting insp. flow (PC board no 5)

To prevent offset voltage drift in the INSP. FLOW signal, the INSP. FLOW LINEARIZATION amplifier is accoupled and set to zero by the zero setting circuits (V42 and V30) during the pause and expiratory time periods, except at the very first moment of the pause, i.e. until the inspiratory valve has closed.

Insp. minute volume adjustment (PC board no 5)

In the INSP. MINUTE VOLUME ADJUSTMENT block (V24:7), the INSP. FLOW signal is scaled to correspond to the setting of the PRESET INSP. MIN. VOL. l/min potentiometer. Increasing PRESET INSP. MINUTE VOLUME will give increasing attenuation of the INSP. FLOW signal in this block.

Volume compensator (PC board no 5)

The volume compensation is achieved in the following way: The difference between the adjusted flow signal INSP. FLOW SCALED and the reference flow signal is integrated (V24:14), resulting in a measure of the volume difference (volume=integrated flow).

This resulting volume difference will influence the momentary inspiratory flow in order to maintain an INSP. MINUTE VOLUME according to PRESET INSP. MIN. VOL. l/min setting.

During VOL. CONTR. and VOL. CONTR.+SIGH modes, the desired MINUTE VOLUME will thus be achieved within approximately 8 breaths from each change of ventilation parameter (at ventilator and/or patient).

During SIMV and SIMV+PRESS. SUPPORT modes, the VOLUME COMPENSATOR will accomplish compensation within each mandatory inspiration only.

Volume compensation selector (PC board no 5)

The actual value from either MAN. VENT. VOLUME COMPENSATOR or the common VOLUME COMPENSATOR is choosen (by V25:6,11) in this stage.

Man. vent. volume compensator (PC board no 7)

During manual ventilation mode, the volume compensation for filling of the breathing bag is calculated in this block (V1a, V1b).

Insp. flow error calculator (PC board no 5)

The INSP. FLOW ERROR CALCULATOR is enabled by a control signal from the block CONSTANT FLOW PATTERN (V32) during INSP. TIME.

The positive going INSP. FLOW SCALED value (differentiated via C5/R72+proportional via R71) is added to the negative going SELECTED FLOW REFERENCE and the VOLUME COMPENSATION value from the VOLUME COMPENSATION SELECTOR, resulting in the INSP. FLOW ERROR SIGNAL (V24:1) to the ERROR SIGNAL SELECTOR. During pause and expiration, the INSP. FLOW ERROR CALCULATOR is blocked by the control signal from the block CONSTANT FLOW PATTERN (V32) which then keeps the ERROR SIGNAL at a fixed negative level.

Flow pattern selection (Front panel)

The FLOW PATTERN SELECTION is made on the front panel with the FLOW PATTERN SWITCH and also by the MODE SELECTOR which will give a constant flow during mandatory inspirations in SIMV modes and also a constant filling flow to the manual breathing bag during MAN mode.

□ = Not valid for SV 900 D ▨ = Not valid for SV 900 E

Insp. pressure ref. level (PC board no 5)

The block outputs are INSP. PRESSURE REFERENCE LEVEL (V25:3) and the negative going INSP. PRESSURE REFERENCE (V18:1).

At SIMV+CPAP MODE (V27:12), both block outputs correspond to PEEP LEVEL (V25:2) coming from PC board no 4.

In the modes SIMV+PRESS. SUPPORT, PRESS. CONTR. and PRESS. SUPPORT, both block outputs correspond to the sum of PEEP LEVEL and INSP. PRESS. LEVEL (V21:14).

During SIMV+PRESS. SUPPORT and PRESS. SUPPORT and CPAP modes (V20:14) at INSP. PRESS. LEVEL front panel settings below 8 cm H_2O, the negative going INSP. PRESS. REFERENCE LEVEL is increased (V21:7) with 1 cm H_2O.

When the button GAS CHANGE is activated, the block GAS CHANGE PRESSURE REF. LEVEL delivers a voltage corresponding to +20 cm H_2O at the negative going INSP. PRESSURE REFERENCE output (V18:1).

Insp. press. level compensator (PC board no 5)

During PRESSURE REG. INSP. TIME the INSP. PRESSURE LEVEL COMPENSATOR connects the sum of the negative going INSP. PRESSURE REFERENCE and AIRWAY PRESSURE (E) during MID. INSP. TIME PULSE (switch V47), to the integrator V36/C20. From the integrator the signal is fed to the INSP. PRESS. ERROR CALCULATOR where compensation for deviations in actual pressure value, with respect to desired pressure level, takes place.

At mode change, START UP RESET pulse resets the integrator (V46).

Second half insp. time (PC board no 7)

A positive going pulse is generated when the time elapsed during the present INSPIRATION is equal to half of the total time of the foregoing INSPIRATION.

Mid. insp. time pulse (PC board no 5)

The positive front edge of the pulse generated in SECOND HALF INSP. TIME will trigger a pulse (V1, V16) which is fed to INSP. PRESSURE LEVEL COMPENSATOR.

Start insp. time marker (PC board no 5)

A pulse is generated at the beginning of the inspiration time. This pulse is used for the derivating circuit in the block INSP. PRESS. ERROR CALCULATOR, in the block INSP. PRESSURE ERROR AMPLIFICATION SELECTION and in the block END INSP. INDICATOR.

Insp. pressure error calculator (PC board no 5)

The actual AIRWAY PRESSURE (I) value (via R95) is added to the differentiated AIRWAY PRESSURE (E) value (via C18/R135/V28), together with the integrated AIRWAY PRESSURE (E) compensation value from INSP. PRESSURE LEVEL COMPENSATOR (V36:6 via R94) and the negative going INSP. PRESSURE REFERENCE (V18:1 via R93) resulting in the INSP. PRESSURE ERROR SIGNAL (V19:8) to the ERROR SIGNAL SELECTOR.

Insp. press. error ampl. selection (PC board no 5)

This stage selects the gain depending on selected mode and timing signals.

Error signal selector (PC board no 5)

This electronic switch (V26, V27) selects the INSP. PRESSURE ERROR SIGNAL for the pressure servo loop and the INSP. FLOW ERROR SIGNAL for the flow servo loop (see introduction chapter "Regulation of inspiration").

Voltage controlled oscillator (PC board no 6)

The VOLTAGE CONTROLLED OSCILLATOR converts the error signal into a pulse sequence (speed signal at V5 via V3:7, 8) with a variable frequency which is proportional to the error signal voltage. In addition, there is a direction signal (at V4 via V3:1) which, depending on the polarity of the error signal, decides whether the motor should step forward (opening) or backward (closing).

☐ = Not valid for SV 900 D ▒ = Not valid for SV 900 E

Direction & speed selection (PC board no 6)

This is a multiplexer and the output signals are direction and speed. The output signals come from the VOLTAGE CONTROLLED OSCILLATOR during normal operation, from FAST OPENING OSCILLATOR during beginning of INSP. TIME in all PRESSURE REG. CONDITIONS except PRESS. CONTR. mode, and from POWER OFF OPENING OSCILLATOR when mains is switched off or at power failure.

Fast opening oscillator (PC board no 6)

This oscillator is set (R37) to a frequency corresponding to a step motor speed of approximately 480 steps/second.

Fast opening control (PC board no 6)

This stage will initiate a fast opening of the inspiratory valve at the beginning of each PRESSURE REG. INSP., except during PRESS. CONTR. mode. This condition will be kept up until the INSP. FLOW exceeds 0.17 l/second.

Power off voltage (PC board no 6)

This stage delivers stored energy to control the opening of the inspiratory valve (step motor) when the mains is switched off.

Power off opening oscillator (PC board no 6)

The freqency of this oscillator is selected (R92) within 250–400 Hz.

End position protector (PC board no 6)

The purpose of the END POSITION PROTECTOR (V27) is to stop the VOLTAGE CONTROLLED OSCILLATOR when the step motor is at either of the two end positions and the direction signal indicates that the motor should step beyond these positions.

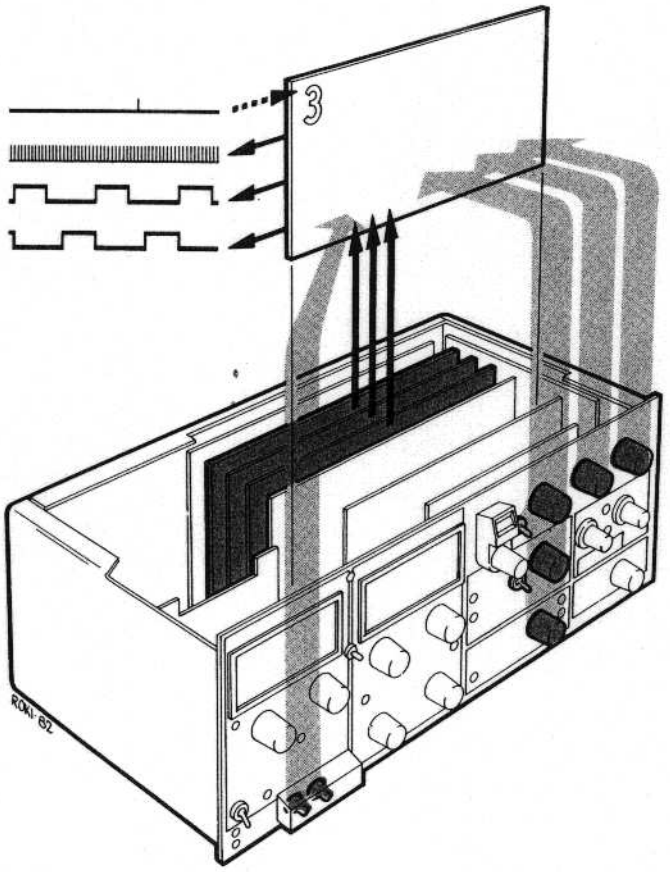
The VOLTAGE CONTROLLED OSCILLATOR is blocked if one of the following conditions is fulfilled:

- The inspiratory valve is fully open and the direction signal indicates additional opening.
- The inspiratory valve is fully closed and the direction signal indicates additional closing.
- The inspiratory valve is fully closed and the inspiration time signal is low.

Step motor driver (PC board no 6)

The STEP MOTOR DRIVER is an up-down counter (consisting of C-MOS circuits V22 and V23 and an output buffer stage V24). The driver stage receives speed information (the pulse frequency) and direction information (forward or backward) via DIRECTION AND SPEED SELECTION block. The driver stage has 8 outputs, two for each motor winding. The windings are activated in a specific sequence, so that the step motor will move an angle of rotation of 3.75° at each step (positioning).

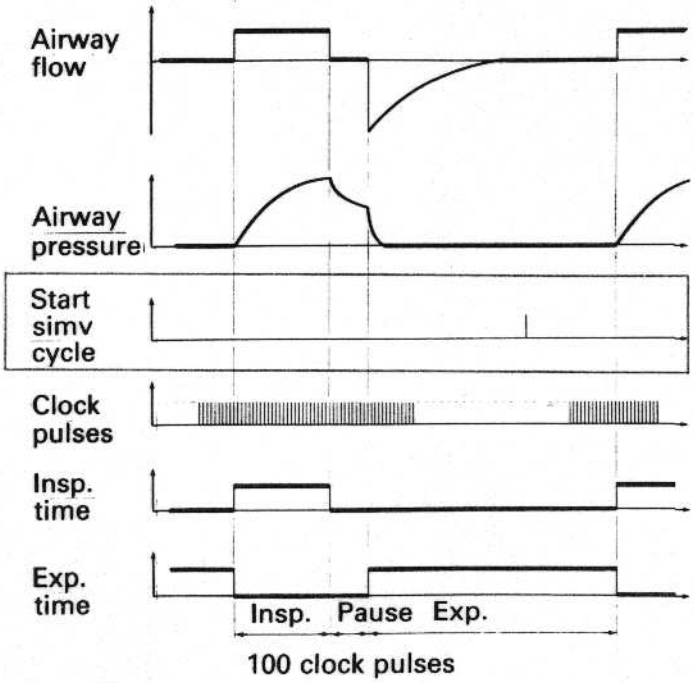
Electronic unit – Timing



General

The circuits in the main block TIMING deliver signals of fundamental significance for the respiratory cycle, i.e. the inspiratory phase (INSP. TIME), the pause period and the expiratory phase (EXP. TIME), see the diagram below.

The INSP. TIME and PAUSE TIME are set on the front panel as percentages of the complete respiratory cycle. The EXP. TIME represents the remainder of the cycle to 100%, equal to 100 clock pulses.



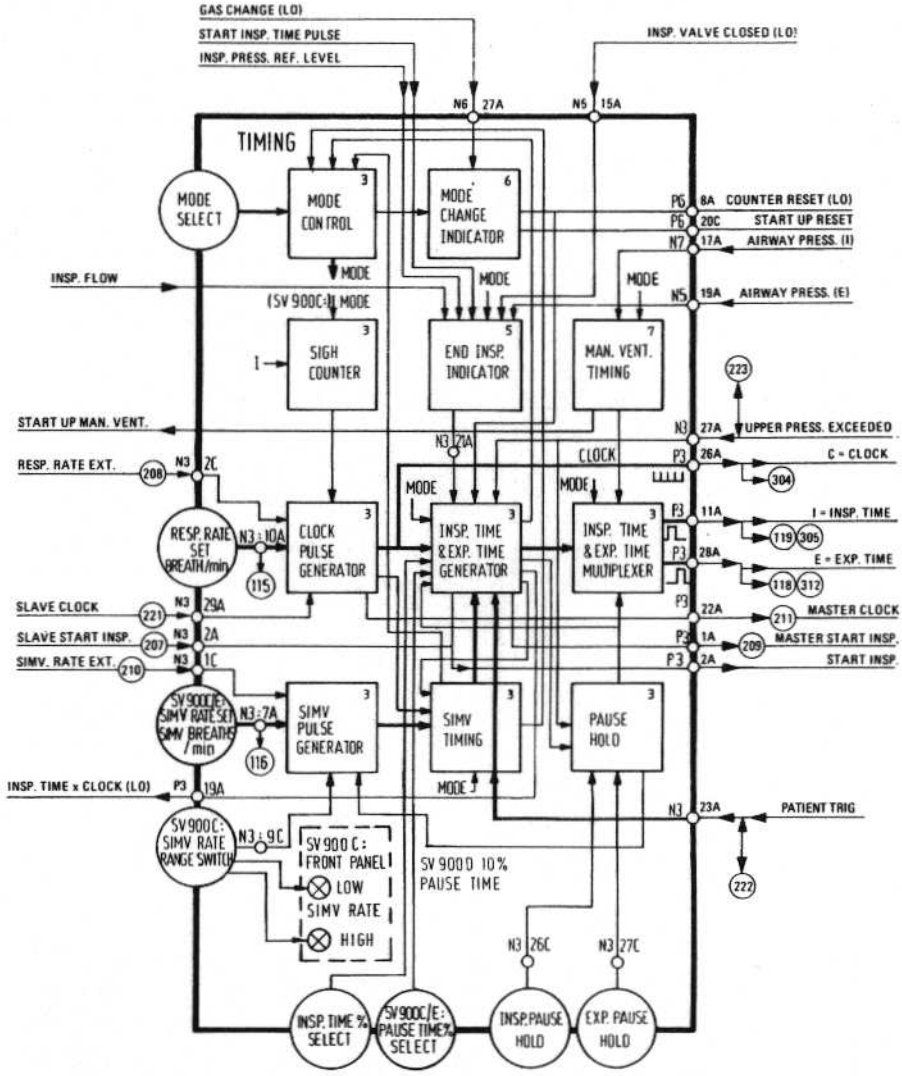
The intervals are controlled by a clock pulse generator.

The percentage settings of INSP. TIME and PAUSE TIME represent the number of clock pulses to be counted in each respiratory cycle.

The normal respiratory cycle of 100 clock pulses can be interrupted in different ways.

See description of block diagram (Insp. time and exp. time generator) page 30.

= Not valid for SV 900 D



"MODE"

In the entire BLOCK DIAGRAM, the designation MODE represents one or more of the following 13 output signals from the MODE CONTROL BLOCK:

PRESS.REG.INSP TIME
PRESS.REG.CONDITION
PRESS.SUPP.MODE SET (LO)
PRESS.CONTR.MODE SET (LO)
VOL.+SIGH MODE SET (LO)
VOL.CONTR.MODE SET (LO)
SIMV+P.MODE SET (LO)
SIMV MODE SET (LO)
SIMV MODE
CPAP MODE SET (LO)
SIMV+CPAP MODE
MODE CHANGE
MAN.VENT.MODE SET (LO)

□ = Not valid for SV 900 D ▨ = Not valid for SV 900 E

Description of block diagram

The text also refers to circuit diagrams.

Clock pulse generator (PC board no 3)

The CLOCK PULSE GENERATOR is a voltage controlled oscillator controlled by the BREATHS/min setting on the front panel. The voltage range is from 0 to +5V corresponding to 5–120 breaths/min. Normally, there will be 100 clock pulses in each breath. Example: A setting of 60 breaths/min corresponds to a frequency of 100 Hz. The width of a clock pulse is approximately 0.1 ms regardless of the clock frequency. The frequency can be externally controlled (via analogue input) or the output signal CLOCK (V44:1) may be externally controlled (via digital input).

The output MASTER CLOCK (LO) is used externally when two ventilators are synchronized.

Sigh counter (PC board no 3)

The SIGH COUNTER, (V24 and V25), counts the number of breaths (positive going edge of the INSP. TIME signal). In the VOL. CONTR.+SIGH mode, the sigh counter delivers a high signal for every hundredth breath during inspiration. This output signal results in a doubling of the clock pulse cycle time during the "sigh inspiration".

Insp. time and exp. time generator (PC board no 3)

The INSP. TIME AND EXP. TIME GENERATOR consists of an insp. and pause time counter (V2, V5), and the flip-flops (V8) for INSP. TIME and EXP. TIME.

In normal controlled MODE operation the following occurs:

- EXP. TIME ends and INSP. TIME starts after every 100th clock pulse (V9) or at a command from SIMV TIMING (V27:11).
- INSP. TIME ends when the number of clock pulses preset on the INSP. TIME % knob have been emitted.
- EXP. TIME starts when the number of clock pulses preset on the PAUSE TIME % have also been emitted.
- A time limitation is always active, except in CPAP or MAN mode and in spontaneous inspiration during SIMV mode. EXP. TIME will be started if the time since the start of INSP. TIME corresponds to 81 % of a breath cycle (V6:3), according to the front panel setting BREATHS/min. This start expiration condition is mentioned on page 32. Also refer to the Operating Manual, page 2:5 (safety function).

The clock pulses are gated (V6:10) with the INSP. TIME signal, resulting in the signal INSP. TIME × CLOCK (LO), which is used to generate the reference flow signals, see Reference level generation.

The normal timing pattern can be interrupted by the commands PATIENT TRIG. (V27:12), UPPER PRESS. EXCEEDED (V11:6), START EXP. SPONT. (V17:13), PAUSE HOLD (V11:1), SLAVE START INSP. (V8:4,10), and COUNTER RESET (via R76).

The MASTER START INSP. (V7:10) signal is used externally when two ventilators are synchronized.

Insp. time & exp. time multiplexer (PC board no 3)

This block is controlled by a MODE-signal. In manual ventilation, the signals from the INSP. TIME & EXP. TIME GENERATOR are disconnected and instead the signals from MAN. VENT. TIMING are connected.

Pause hold (PC board no 3)

This stage is controlled by the knobs INSP. PAUSE HOLD and EXP. PAUSE HOLD. When any of these buttons is depressed, the signal PAUSE HOLD (V19:3) stops the clock pulse to the INSP. TIME & EXP. TIME GENERATOR, synchronized with the respiratory cycle.

SIMV pulse generator (PC board no 3)

This is the same kind of voltage controlled oscillator as the CLOCK PULSE GENERATOR. The signal is divided by 100 (V35) and furthermore by 10 (V36), controlled by the switch HIGH RATE/LOW RATE.

The main output signal from this stage is the START SIMV CYCLE pulse to SIMV TIMING. One pulse is emitted for each SIMV period.

Simv timing (PC board no 3)

During SIMV modes, this block will make sure that one mandatory breath (which means a FLOW REGULATED INSPIRATION) is started during each SIMV-period.

Each START SIMV CYCLE pulse from the SIMV PULSE GENERATOR (V34:10), starts a new SIMV-period which means a synchronizing WAIT-period, waiting for the next mandatory breath to be initiated. The WAIT-period will end if there is a PATIENT TRIG (via V27:5), or at the latest (via V27:4), when 90 clock pulses from the CLOCK PULSE GENERATOR (V44:1) have been counted (V30).

In both cases, the SIMV MANDATORY BREATH TRIG (V27:7), will initiate the mandatory breath with a FLOW REGULATED INSPIRATION. During (SIMV)-spontaneous breathing, the command PRESS. REG. PRECONDITION (V26:12) will enable the PRESSURE SERVO LOOP instead of the FLOW SERVO LOOP.

The SIMV BREATHS/min setting is compared with the BREATHS/min setting in comparator V37. This ensures that when the SIMV RATE is set at a rate, higher than the BREATH RATE SET, the resulting BREATH RATE will be the one coming from BREATHS/min setting.

Mode control (PC board no 3)

In combination with the mode selector on the front panel, this block generates 13 different so called MODE signals used in several places in the ventilator. (Signal names in the INTERCONNECTION DIAGRAM and table on page 29).

Mode change indicator (PC board no 6)

A START UP RESET pulse is generated at mode change, power on and gas change. The result of the COUNTER RESET pulse also generated at mode change and gas change is to reset the 2 minute timer and that the expiration starts immediately. This expiration will be 100 clock pulses long if there is no patient trig.

□ = Not valid for SV 900 D ▒ = Not valid for SV 900 E

End insp. indicator (PC board no 5)

In all modes which include spontaneous breathing, (PRESS. SUPPORT, SIMV and SIMV+PRESS. SUPPORT and CPAP) the moment when the spontaneous inspiration is about to stop is normally determined in this stage (a START EXP. SPONT signal is generated).

Criteria no 1. for this is when the measured flow drops below 25% (V22:2/R53, R76) of the PEAK FLOW during the same inspiration (V16:1/C13) if the PEAK INSP. FLOW is higher than 0.1 l/second.

Closed inspiratory valve and a pressure increase of +3 cm H_2O will also result in a START EXP. SPONT. signal to INSP. TIME & EXP. TIME GENERATOR (criteria no 2). This signal makes INSP. TIME end even if the peak insp. flow is lower than 0.1 l/s.

See table on page 32.

Man. vent. timing (PC board no 7)

This stage receives the AIRWAY PRESSURE (I) signal from the inspiratory pressure transducer. This signal goes to the comparator (V1d:12, 13, 14) which controls the manual ventilation EXP. TIME., and to (V1c:10, 9, 8), which controls the manual ventilation INSP. TIME.

The INSPIRATION TIME in this case, means the time during which the manual breathing bag will be filled.

This will start when the pressure drops below approximately 2 cm H_2O and it will stop when the pressure rises above approximately 4 cm H_2O(comparator V1c).

The expiration will take place if the pressure drops below approximately 4 cm H_2O and will stop if the pressure rises above approximately 6 cm H_2O (comparator V1d).

= Not valid for SV 900 D = Not valid for SV 900 E

Start insp. & end insp. conditions, *and the front panel settings on which they depend*

The start insp. conditions (V=ventilator and P=patient) are monitored in the following blocks:

(V) INSP. TIME & EXP.TIME GENERATOR (PC board no 3)

(P) TRIG. LEVEL MONITORING (PC board no 4)

P_I = AIRWAY PRESSURE (I)
P_E = AIRWAY PRESSURE (E)
Patient TRIG =
P_E < [PEEP LEVEL] — [TRIG SENSITIVITY]

The end insp. conditions (0-5) are monitored in the following blocks:

(0): INSP. & EXP.TIME GENERATOR (PC board no 3)

(1): END INSP. INDICATOR (PC board no 5)

(2): END INSP. INDICATOR (PC board no 5)

(3): UPPER PRESSURE MONITORING (PC board no 4)

(4): HIGH INSP.PRESS.PROTECTION (PC board no 5)

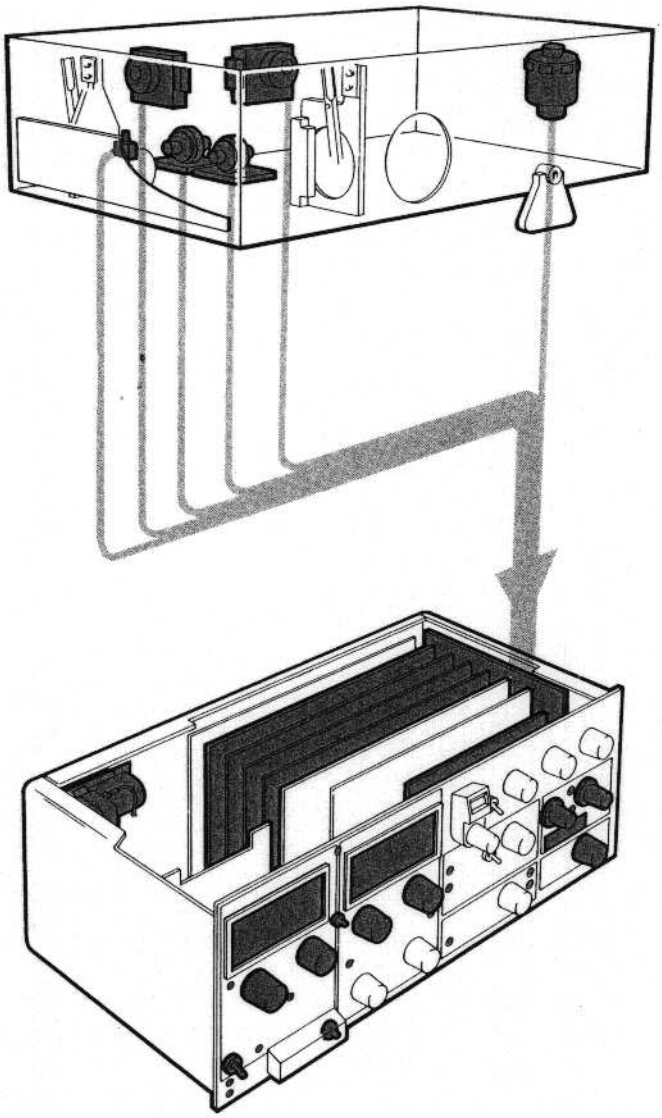
(5): INSP. TIME. & EXP.TIME GENERATOR (PC board no 3)

Mode	Start insp. condition	End insp. condition *)
PRESSURE CONTROL	(V) Ventilator START INSP. *Preset BREATHS/min.* (P) Patient TRIG; *Preset TRIG. SENSITIVITY*	(0) Ventilator STOP INSP; *Preset INSP.TIME %* (3) P_E or P_I > [UPPER PRESS. LIMIT]; *Preset UPPER PRESS.LIMIT* (4) P_I > [30 cm H_2O] + [PEEP LEVEL] + [INSP.PRESS.LEVEL above PEEP]; *Preset PEEP and INSP.PRESS.LEVEL*
PRESSURE SUPPORT or pressure regulated inspiration during SIMV+ PRESS. SUPPORT	(P) Patient TRIG; *Preset TRIG. SENSITIVITY*	(1) INSP.FLOW < 25 % × [PEAK INSP.FLOW during same inspiration]; (This condition only at PEAK INSP.FLOW > 0.1 l/s) (2) [INSP.VALVE CLOSED] & P_E > ([3 cm H_2O] + [PEEP LEVEL] + [INSP.PRESS LEVEL above PEEP]); *Preset PEEP and INSP.PRESS.LEVEL above PEEP* (3) P_E or P_I > [UPPER PRESS.LIMIT]; *Preset UPPER PRESS.LIMIT* (4) P_I > ([30 cm H_2O] + [PEEP LEVEL] + [INSP.PRESS.LEVEL above PEEP]); *Preset PEEP and INSP.PRESS.LEVEL* (5) Duration of [INSP.TIME] > (80 % × [BREATH CYCLE]); *Preset BREATHS/min*
CPAP or pressure regulated inspiration during SIMV	(P) Patient TRIG; *Preset TRIG.SENSITIVITY*	(1) INSP.FLOW < 25 % × [PEAK INSP.FLOW (during same inspiration)]; only at PEAK INSP.FLOW > 0.1 l/s (2) [INSP. VALVE CLOSED] & P_E > ([3cm H_2O] + [PEEP LEVEL]); *Preset PEEP* (3) (P_E or P_I) > [UPPER PRESS.LIMIT]; *Preset UPPER PRESS.LIMIT* (4) P_I > ([30 cm H_2O] + [PEEP LEVEL]); *Preset PEEP*
VOL.CONTR. (+SIGH) or flow regulated inspiration during SIMV (+PRESS. SUPPORT)	(V) Ventilator START INSP.; *Preset BREATHS/min* (P) Patient TRIG; *Preset TRIG.SENSITIVITY*	(0) Ventilator STOP INSP.; *Preset INSP.TIME%* (3) (P_E or P_I) > [UPPER PRESS.LIMIT]; *Preset UPPER PRESS.LIMIT*

*) The conditions 1-5 lead directly to start of expiration.
The condition 0 leads to PAUSE. *Preset PAUSE TIME%.*
Start expiration condition (safety function) during PAUSE:
(Duration of [INSP.TIME + PAUSE TIME]) > (80% × [BREATH CYCLE])
Preset INSP.TIME% + PAUSE TIME%.
This start exp condition is monitored in the same way as end insp condition 5.

= Not valid for SV 900 D = Not valid for SV 900 E

Electronic unit – Monitoring



General

The monitoring subsystem of the Servo Ventilator 900 C/D/E is used for continuous monitoring and indication, via the front panel meters, of the pressure and flow signals.

The expiratory flow transducer continuously measures the expiratory flow. The flow is linearized and the value is shown on the meter EXPIRED MINUTE VOLUME and on the digital display as EXP. TIDAL VOL. ml and EXP. MIN VOL. l/min.

The monitoring system operates independent of the regulating systems.

On the digital display, 8 parameters can be selected for direct read-out.

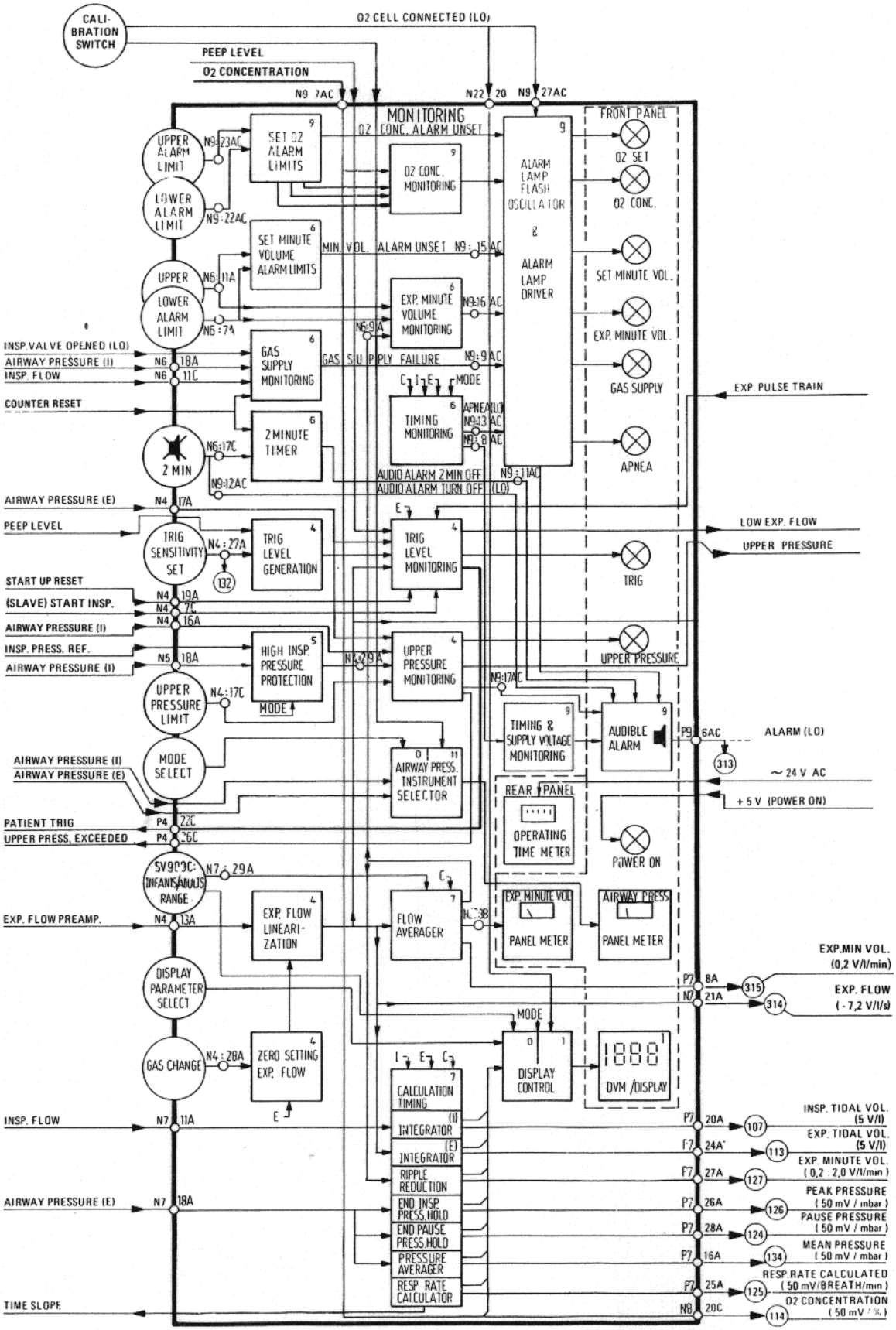
The values are continuously compared with preset alarm limits, and if any of these limits is exceeded, a corresponding visual and audible alarm is activated.

As described in the section TIMING, the timing schedule is affected when one of the limit values UPPER PRESSURE EXCEEDED or PATIENT TRIG. is exceeded.

All internal voltages, and timing control signals are monitored and an audible alarm is activated if any of these should fail.

The audible alarms, with some exceptions, can be silenced for approximately 2 minutes by means of the knob OFF 2 MIN on the front panel. UPPER PRESS.LIMIT and TIMING FAILURE audible alarm as well as the initiation of an alarm for VOLTAGE failure can not be silenced in this way.

Electronic unit – Monitoring



Description of block diagram

The text also refers to circuit diagrams.

Set O_2 alarm limits (PC board no 9)

The settings on the front panel knobs for O_2 CONC. ALARM LIMITS are sensed in this block.

The output signal O_2 CONC. ALARM UNSET is a digital signal (V15:10) which will be active (LO) if:

- the front panel knob LOWER ALARM LIMIT for O_2 CONC. is close to its left (counter clockwise) end position (out of scale) and/or
- the front panel knob UPPER ALARM LIMIT for O_2 CONC. is close to its right (clockwise) end position (out of scale).

This output signal (V15:10) activates the yellow lamp SET O_2 ALARM on the front panel via the block ALARM LAMP DRIVER.

The output signals furthered to the block O_2 CONC. MONITORING correspond to:

- O_2 conc. lower limit
- O_2 conc. upper limit
- signal level corresponding to 18% O_2 (21% if R61 = 1 kΩ is in use).

O_2 conc. monitoring (PC board no 9)

The input signal is the O_2 CONC. from the amplifier for O_2 concentration. The scale factor is 50 mV/%.

The signal is compared with the preset alarm limits from the block SET O_2 ALARM LIMITS. An alarm pulse is generated to the ALARM LAMP DRIVER (for O_2 CONC. ALARM) if the signal O_2 CONC. value is:

- less than the setting of the front panel knob LOWER ALARM LIMIT for O_2 concentration or
- more than the setting of the front panel knob UPPER ALARM LIMIT for O_2 concentration or
- below 18% independent of front panel setting (21% if R61 = 1 kΩ is in use).

Set minute volume alarm limits (PC board no 6)

The settings on the front panel knobs concerning ALARM LIMITS for EXPIRED MINUTE VOLUME are sensed in this block.

The output signal is the signal MINUTE VOL. ALARM UNSET (V10-L37&L38) which will be active (HI) if:

- the front panel knob LOWER ALARM LIMIT for EXPIRED MINUTE VOLUME is close to its left (counter clockwise) end position (out of scale) and/or
- the front panel knob UPPER ALARM LIMIT for EXPIRED MINUTE VOLUME is close to its right (clockwise) position (out of scale).

The signal MINUTE VOL. ALARM UNSET activates a flashing yellow light, SET MIN. VOL. ALARM on the front panel via the block ALARM LAMP DRIVER.

Exp. minute volume monitoring (PC board no 6)

The actual value EXP. MINUTE VOL. MONITOR from the EXP. FLOW AVERAGER and the settings of the front panel knobs concerning the ALARM LIMITS for EXPIRED MINUTE VOLUME are sensed in the EXP. MINUTE VOLUME MONITORING block.

The output (V9:7) is the signal EXP. MIN. VOL. LIMIT EXCEEDED which will be active (HI) if the actual value of EXP. MINUTE VOL. MONITOR is:

- more than the setting of the front panel knob UPPER ALARM LIMIT for EXPIRED MINUTE VOLUME.
- less than the setting of the front panel knob LOWER ALARM LIMIT for EXPIRED MINUTE VOLUME.

The signal EXP. MINUTE VOL. LIMIT EXCEEDED activates a red flashing lamp, EXP. MINUTE VOLUME ALARM, on the front panel and the AUDIBLE ALARM via the block ALARM LAMP DRIVER.

Gas supply monitoring (PC board no 6)

The actual value of INSP. FLOW from INSP. FLOW LINEARIZATION and the actual value of AIRWAY PRESSURE (I) from AIRWAY PRESSURE (I) AMPLIFIER as well as the control signal INSP. VALVE OPENED (LO) from END POSITION PROTECTOR are sensed.

The output signal (V7:7) GAS SUPPLY FAILURE, will be active during all modes except MAN. VENT. MODE if the following occurs at the same time:

- INSP. FLOW is less than 0.3 l/second,
- AIRWAY PRESSURE (I), is less than 22 cm H_2O and
- INSP. VALVE is fully open.

The signal GAS SUPPLY FAILURE activates the flashing red alarm lamp, GAS SUPPLY ALARM, on the front panel and the AUDIBLE ALARM via the block ALARM LAMP DRIVER.

= Not valid for SV 900 E

2 minute timer (PC board no 6)

The input signals are AUDIO ALARM TURN OFF (LO) from the front panel pushbutton OFF 2 MIN and COUNTER RESET from (R 80) MODE CHANGE INDICATOR.

The output signal (V28:10) AUDIO ALARM 2 MIN OFF, will be active during (up to) 2 minutes from each time the pushbutton is depressed. During the active time of the output signal, the timer can be reset by the signal COUNTER RESET. The signal AUDIBLE ALARM 2 MIN OFF will silence the following alarms for 2 minutes:

EXP. MINUTE VOLUME ALARM

APNEA ALARM

GAS SUPPLY ALARM

O_2 CONC ALARM

Timing monitoring (PC board no 6)

In all modes except the MAN. VENT. MODE the control signals CLOCK, INSP. TIME, and EXP. TIME are monitored.

The signal TIMING FAILURE (LO) (V28:6), will be active:

–if more than 0.5 second has passed since the last start of a CLOCK PULSE or

–if the control signals INSP. TIME and EXP. TIME should both be active at the same time.

The signal TIMING FAILURE (LO) activates the AUDIBLE ALARM via the block TIMING & SUPPLY VOLTAGE MONITORING.

The signal APNEA (LO), (V30:9), will be active:

–if more than 15 seconds has passed since the last start of INSP. TIME and/or

–if more than 15 seconds has passed since the last start of EXP. TIME.

The signal APNEA (LO) activates the red flashing alarm lamp, APNEA ALARM, on the front panel and the AUDIBLE ALARM via the block ALARM LAMP DRIVER.

Timing & supply voltage monitoring (PC board no 9)

In case of TIMING FAILURE, (from TIMING MONITORING) or if any of the four regulated internal supply voltages fails, AUDIBLE ALARM will be activated.

Alarm lamp flash oscillator (PC board no 9)

This oscillator generates a frequency (approximately 2 Hz) for lamp flashes and audible alarms.

Alarm lamp driver (PC board no 9)

The input alarm signals are gated together with the signal from ALARM LAMP FLASH OSCILLATOR causing the activated alarm lamps to light up and flash.

All alarms, except SET ALARM LIMITS include audible alarm.

Audible alarm (PC board no 9)

The bleep-tone is driven from V17 or V11. The capacitors C1–C6 supplies the alarm circuit with power for approximately 5 minutes when mains is switched off or at mains failure.

Operating time meter (Power supply unit)

The meter reading (on the rear panel), indicates the accumulated time that the power has been switched on.

Trig. level generation (PC board no 4)

The input signals are, the command value (0–2.5V) TRIG. SENSITIVITY SET from the front panel knob TRIG. SENSITIVITY BELOW PEEP (–20—0 cm H_2O) and the reference value (–0,5—2.5V) PEEP LEVEL (–10—+50 cm H_2O) from PEEP LEVEL GENERATION.

The output signal (V6:1) is the reference value TRIG. LEVEL, corresponding to the absolute TRIG. SENSITIVITY value subtracted from the PEEP value.

= Not valid for SV 900 E

Trig. level monitoring (PC board no 4)

The signal PATIENT TRIG. (V14:14/L53) and TRIG. LAMP (V22:16), will both be high each time the actual value AIRWAY PRESSURE (E) falls below the reference value TRIG. LEVEL with the following exception:

To prevent trig. while the patient is exhaling, the trig. is blocked:

–by (V17:10) during the first 5 seconds after start of expiration—during expiration only—as long as the actual EXP. FLOW value is more than 0.05 l/s. (V17 is reset by START INSP. control signal).

– (via V13:14) if the actual value AIRWAY PRESSURE (E) has been increasing (V13:1, 7, 8) = oscillating during expiration.

The signal PATIENT TRIG. is fed to the main block TIMING and used for start of an inspiration and the signal TRIG. LAMP (LO) lights the yellow lamp at the TRIG. SENSITIVITY knob on the front panel.

High insp. pressure protection (PC board no 5)

The inputs are, PRESS. REG. INSP. TIME (inverted in the block MID INSP. TIME PULSE), the actual value AIRWAY PRESSURE (I) and the desired inspiratory pressure value represented by the negative going INSP. PRESSURE REFERENCE signal (via R90).

The output signal HIGH PRESSURE STOP INSP. (V18:8/L33), will be active during PRESSURE REGULATED INSPIRATION (controlled via L13) if the actual value AIRWAY PRESSURE (I) exceeds the desired inspiratory pressure value by more than 30 cm H_2O.

The output signal HIGH PRESSURE STOP INSP. will initiate a condition to stop the pressure regulated inspiration and start the expiration.

Upper pressure monitoring (PC board no 4)

The input signals are HIGH PRESSURE STOP INSP., the actual values AIRWAY PRESSURE (I) and (E) and the command value UPPER PRESSURE LIMIT SET from the front panel knob UPPER PRESS LIMIT (15–120 cm H_2O).

The output signals UPPER PRESSURE EXCEEDED (V9:7/L39, or (V23:6/L39) UPPER PRESSURE ALARM (V22:14) and UPPER PRESSURE ALARM LAMP (V22:15) will all be active as long as:

–the actual value AIRWAY PRESSURE (I) and/or (E) exceeds the command value UPPER PRESSURE LIMIT SET and/or

–HIGH PRESSURE STOP INSP. is active.

The output signal UPPER PRESSURE EXCEEDED is used for initiating an expiration (in the block INSP. TIME & EXP. TIME GENERATOR).

The signal UPPER PRESSURE ALARM activates the AUDIBLE ALARM.

The signal UPPER PRESSURE ALARM LAMP (LO) lights the red lamp at the knob UPPER PRESS. LIMIT on the front panel.

Airway pressure instrument selector

This block is a symbol for the function of:

–one part of the CALIBRATION SWITCH (in the pneumatic unit) and

–one part of the front panel MODE SELECTOR.

The normal output signal corresponds to AIRWAY PRESSURE (I) from the inspiratory PRESSURE TRANSDUCER (I). The output signal during MAN. mode or when the calibration switch is depressed, corresponds to AIRWAY PRESSURE (E) from the expiratory PRESSURE TRANSDUCER (E).

= Not valid for SV 900 E

Airway pressure panel meter

The panel meter for AIRWAY PRESSURE displays the inspiratory or expiratory pressure, depending on the selected mode and the calibration switch.

Exp. flow linearization (PC board no 4)

The signal from the expiratory flow transducer is linearized (by V8:1).

Zero setting exp. flow (PC board no 4)

To prevent offset voltage drift in the EXP.FLOW signal, the EXP.FLOW LINEARIZATION amplifier is ac–coupled and set to zero during inspiration and pause by means of the zero setting circuit (V19). Zero setting also takes place in this block (by V18) when the GAS CHANGE pushbutton is depressed.

Flow averager (PC board no 7)

The FLOW AVERAGER is a low pass filter. Its time constant is depending on the CLOCK-frequency (preset BREATHS/min on the front panel). The output EXP. MINUTE VOL. (0.2V/l/min) is the mean value of the input EXP. FLOW (–7.2V/l/s). The outputs EXP. MINUTE VOL. INSTRUMENT (front panel meter) and EXP. MINUTE VOL. MONITOR (V14:1) are influenced by the switch INFANTS/ADULTS which will increase the sensitivity by ten times in the INFANTS range.

Expired minute volume panel meter

The panel meter showing EXPIRED MINUTE VOLUME has two scales (0–4 and 0–40 l/min).

Calculation timing (PC board no 7)

This block produces timing signals for the different calculating stages.

Integrator (I) (PC board no 7)

The INSP. TIDAL VOLUME is an integration of the INSP. FLOW signal during each inspiration.

Integrator (E) (PC board no 7)

The EXP. TIDAL VOLUME is an integration of the EXP. FLOW signal during each expiration.

Ripple reduction (PC board no 7)

This is a special low pass filter, creating a stable output value (V34:5), EXP. MINUTE VOL. (0.2V/l/min; 2V/l/min). The output (EXP. MINUTE VOL. DISPLAY) can be shown on the DIGITAL DISPLAY at the front panel.

End insp. pressure hold (PC board no 7)

This block is an analogue memory.

The PEAK PRESSURE is the AIRWAY PRESSURE (E) value at the end of inspiration.

End pause pressure hold (PC board no 7)

This block is an analogue memory.

The PAUSE PRESSURE is the AIRWAY PRESSURE (E) value at the end of the pause.

Pressure averager (PC board no 7)

The PRESSURE AVERAGER is a low pass filter. Its time constant is depending on the frequency of the stretched CLOCK pulses (by V9:10 in the block CALCULATION TIMING) (preset BREATHS/min on the front panel).

The output MEAN AIRWAY PRESSURE is a mean value of the AIRWAY PRESSURE (E).

Resp. rate calculator (PC board no 7)

The RESP. RATE (CALCULATED) is an analogue frequency value corresponding to a "beat to beat" time of each respiratory cycle.

Display control (PC board no 1)

Via the front panel selector for DISPLAY PARAMETER,

–the parameter to be shown is selected

–the decimal point position is influenced by the front panel switch INFANTS/ADULTS (for EXPIRED MINUTE VOLUME) and

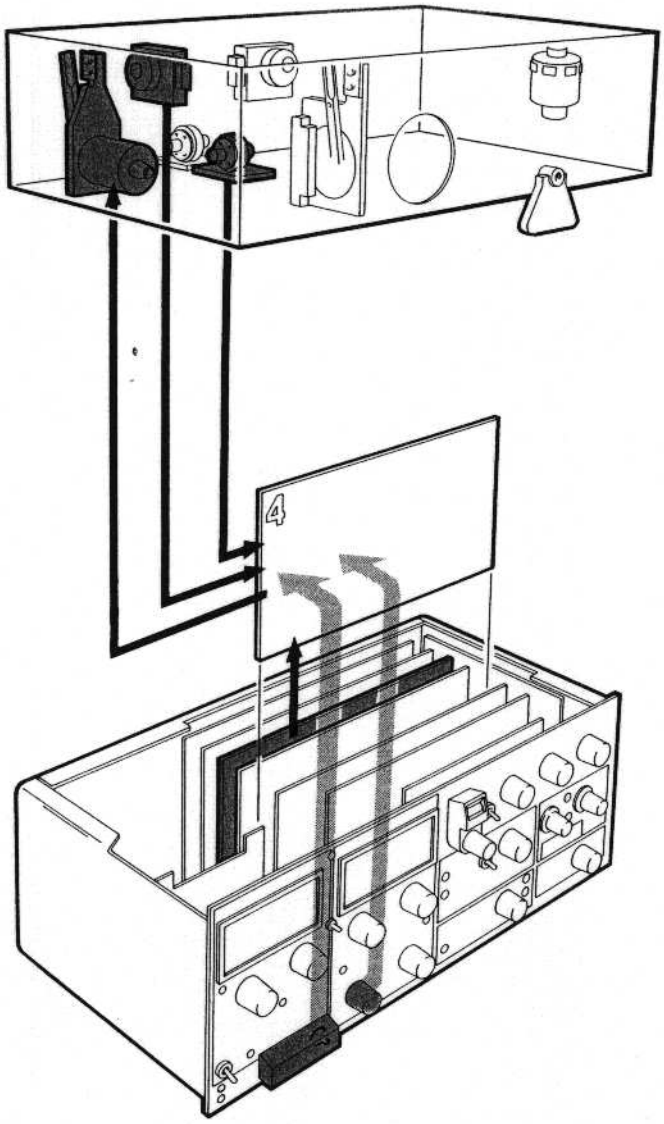
–the blanking of the DVM/DISPLAY is influenced by O_2 CELL CONNECTED and during MAN. mode.

DVM/Display (PC board no 1)

This is a Digital Volt Meter with 3 $^1/_2$ digits. Depending on the front panel selector for DISPLAY PARAMETER one out of eight analogue parameters will be displayed as a corresponding digital value.

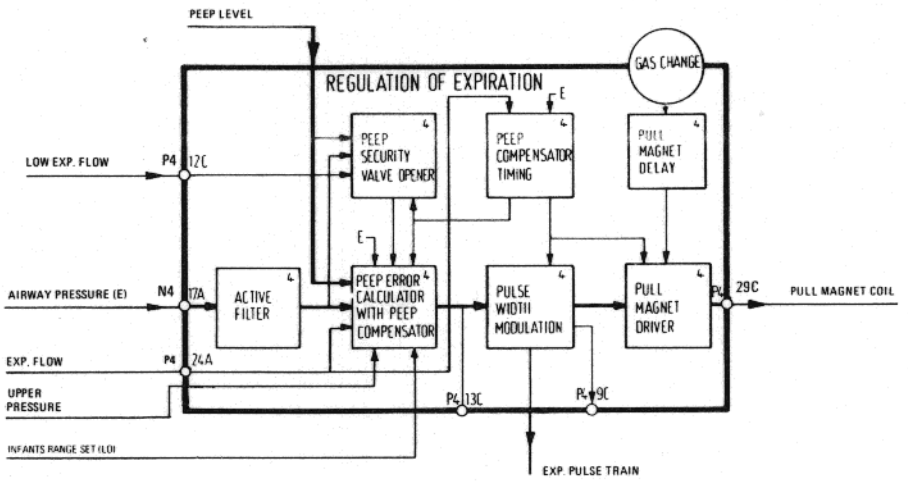
= Not valid for SV 900 D = Not valid for SV 900 E

Electronic unit – Regulation of expiration



General

The pressure signal from the pressure transducer in the expiratory channel is compared with the preset PEEP level, and a difference results in a correction signal to the expiratory valve to maintain the set PEEP level.



Description of block diagram

The text also refers to the circuit diagrams.

Active filter (PC board no 4)

The AIRWAY PRESSURE (E) signal is filtered with respect to 40 Hz signal (ripple), from expiratory valve.

Peep error calculator with peep compensator (PC board no 4)

The PEEP level signal from PEEP LEVEL GENERATION (V6:8 via R18) is added to the actual inverted value of AIRWAY PRESSURE (E) from ACTIVE FILTER (V8:8 via R17) which gives the proportional action (via R21) for the PEEP regulation. The proportional action has two levels of amplification. The higher level of amplification is intended to increase the opening of the expiratory valve during the very first 50–70 ms of EXP. TIME. During the rest of EXP. TIME the normal level of amplification is used (activated via V2 by control signal from V5:14). An additional activating circuit (V25 controlled from the signal INFANTS RANGE SET (LO) at P4:22A) results in the normal level of amplification being used continuously during the entire EXP. TIME if the EXP. MINUTE VOLUME is less than approximately 4 l/min (comparator V12:14) as well as if INFANTS is selected at the SV 900 C front panel INFANTS/ADULT switch.

At each breath the difference between actual AIRWAY PRESSURE (E) (inverted value via R12) and the desired PEEP (value via R15) together with a minor influence from EXP. FLOW (value via R58) is (enabled via V16 and) integrated in the PEEP COMPENSATOR (V10/C21). The PEEP COMPENSATOR continuously stores a signal level which is used (via R62) for biasing the PULL MAGNET COIL during PEEP regulation.

The combined PEEP regulating signal (V11:1) will influence pull magnet via PULSE WIDTH MODULATION to obtain the desired PEEP level.

Pulse width modulation (PC board no 4)

The pulse width modulator converts the signal from the PEEP ERROR CALCULATOR to a pulse sequence with a fixed frequency.

Pull magnet driver (PC board no 4)

The driver stage converts the pulses into a current through the pull magnet coil. The pull magnet keeps the expiratory valve closed during inspiration and pause.

The opening angle of the pull magnet is determined by the width of the current pulses through the coil. The greater the error signal, the shorter the pulse and consequently, the bigger the opening angle.

The signal GAS CHANGE causes the valve to open.

Peep compensator timing (PC board no 4)

These are the control circuits for the integrator in the PEEP ERROR CALCULATOR WITH PEEP COMPENSATOR block.

The input (V16) of the integrator (V10/C21) of the PEEP ERROR CALCULATOR WITH PEEP COMPENSATOR block is switched on (by V17/V9) at the beginning of EXP. TIME. It will be switched off when the EXP. FLOW is less than 0.014 l/second (by V6:14) or at the latest after 250 ms (by V17/V9). It is grounded (via V1) during the first 50–70 ms of EXP. TIME (by V5:14).

Peep security valve opener (PC board no 4)

This stage ensures that the integrator in the PEEP CALCULATOR WITH PEEP COMPENSATOR block is discharged (V15) if the pressure exceeds 4 cm H_2O above the set PEEP level (by V11:7).

As the pressure at the beginning of expiration is normally more than 4 cm H_2O above PEEP level, the integrator discharge circuit (V15) is blocked during the first part of the expiration from PEEP COMPENSATOR TIMING (V5:14/L43).

It is also blocked during INSP. TIME and PAUSE TIME and as long as EXP. FLOW is more than 0.05 l/second (V14:7 in the block TRIG LEVEL MONITORING).

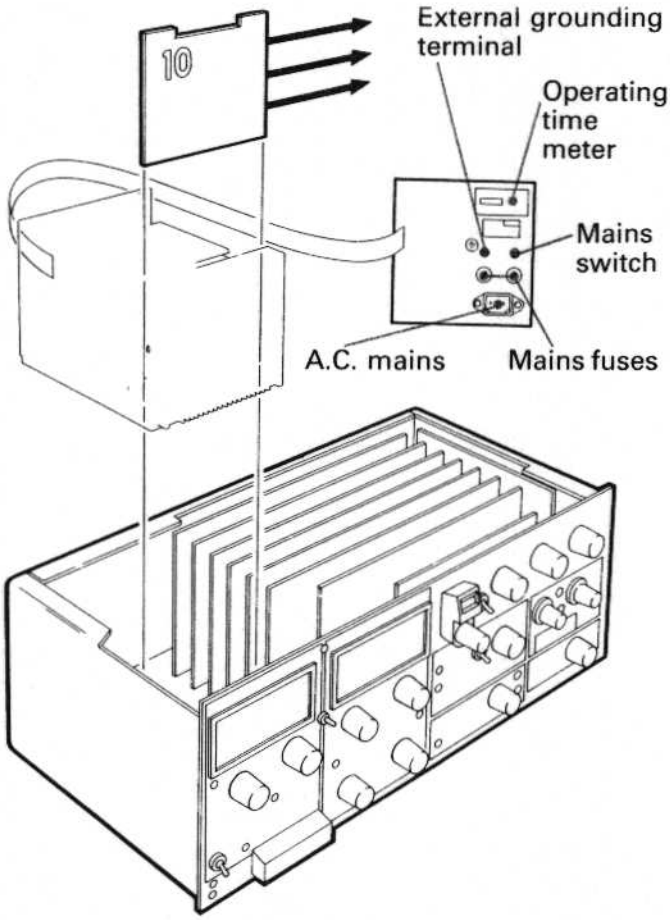
Pull magnet delay (PC board no 4)

A delay pulse of approximately 1.5 s is generated each time the input signal GAS CHANGE (V5:7) goes low. The delay pulse goes to the PULL MAGNET DRIVER block. Thus, each time the front panel knob GAS CHANGE is released (= at the end of GAS CHANGE), the PULL MAGNET DRIVER is disabled and the expiratory valve is kept open during this delay pulse. The time is long enough for the AIRWAY PRESSURE to drop to a low pressure level.

= Not valid for SV 900 D

= Not valid for SV 900 E

Electronic unit – Voltage supply

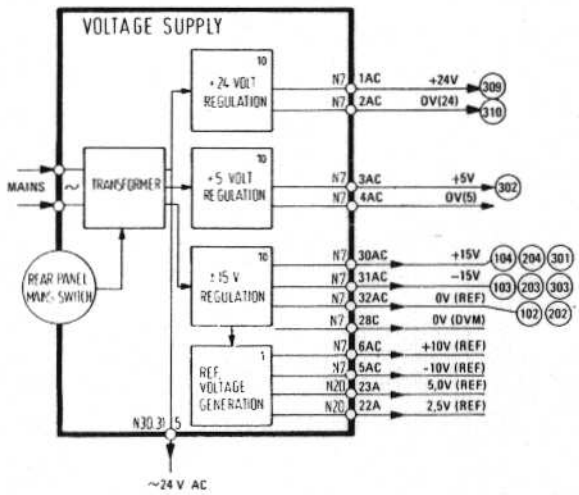


General

The Servo Ventilator 900 C/D/E can be connected to mains 110, 120, 220 or 240 V AC 50/60 Hz with a protective ground. (A special version for 100 V AC is available).

The voltage supply system provides the subsystems with supply voltages +24, +5 and ±15V.

If any of the internal voltage supplies fails, an alarm is immediately activated.



Transformer (Power supply unit)

The voltage can be selected internally at the transformer mains input. There are fuses for the transformer, externally (in fuse holder) and internally (three thermal fuses).

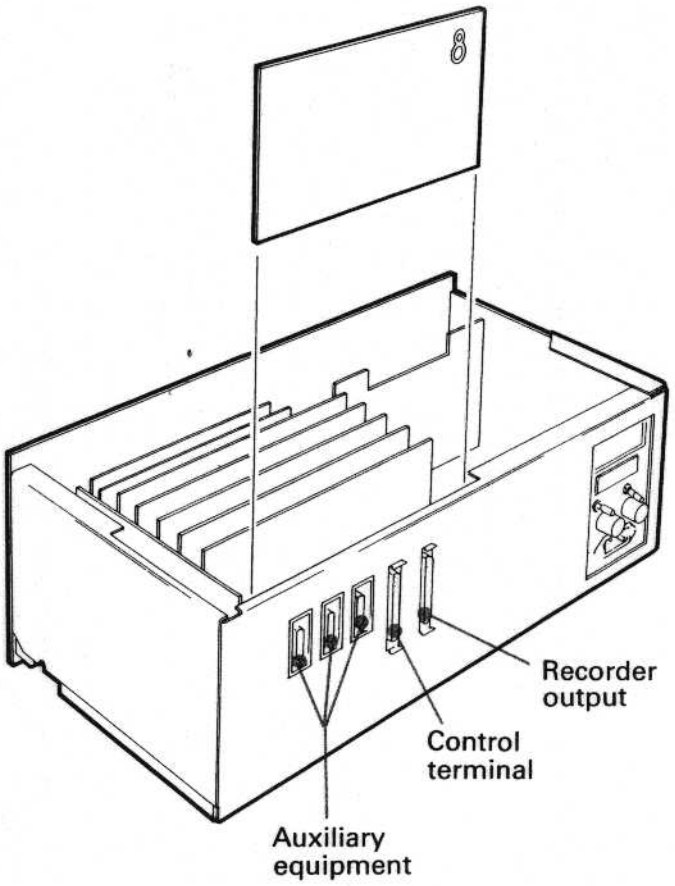
+24V, +5V, ±15V regulation (PC board no 10)

The four internal supply voltages are all regulated and protected against over–voltage at the outputs by diods (L4, L5, L6 and L7).

Ref. voltage generation (PC board no 1)

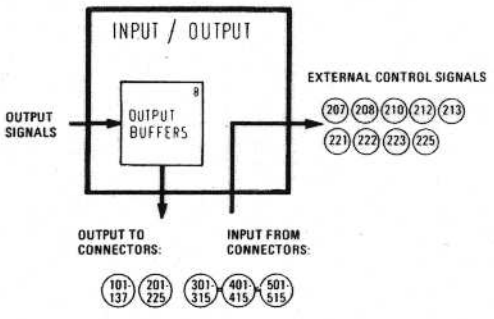
The generated reference voltages ±10V (REF), +5V (REF) and +2.5V (REF) are used at the front panel potentiometer controls and on different PC boards.

Electronic unit – Input/output



General

At the rear panel of the ventilator, there are three 15-pole Cannon sockets for AUXILIARY EQUIPMENT, a 25-pole Cannon socket (under a lid): CONTROL TERMINAL and a 37-pole Cannon socket with RECORDER OUTPUTS.



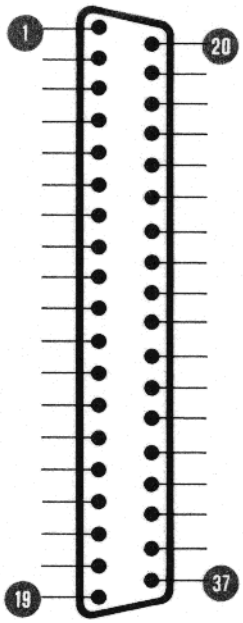
Output buffers (PC board no 8)

The output signals at the 15- pole and 37-pole Cannon sockets are all (except the supply voltages) buffered for security.

External control (Rear panel)

The 25-pole socket marked CONTROL TERMINAL is intended for control of some ventilator functions, for instance when connecting two ventilators in a MASTER-SLAVE configuration.

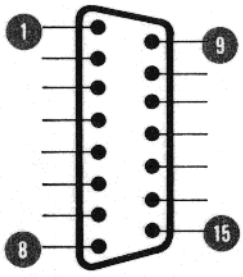
The pins are either for input signals or output signals (pins 22 and 23 are combined). The inputs are intended for low-resistance (less than 100 ohm) voltage, lower than ±12V. Higher voltages might be hazardous to the electronic circuits and must not be used.



Recorder output

The recorder output (37–pole Cannon), contains outputs for flow, pressure and some control signals. The outputs are adapted to Siemens-Elema Mingograf recorders.

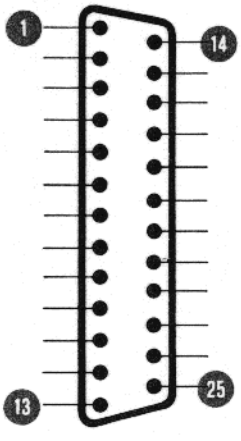
The pins (1–37) of the connector are numbered 101–137 in the diagrams.



Auxiliary equipment

The 15-pole Cannon connectors, three in parallel, contains outputs for flow and pressure and some control signals.

The pins (1–15) of three connectors are numbered 301–315, 401–415 and 501–515 in the diagrams.



Control terminal

The 25-pole Cannon connector contains inputs for external control of some functions as well as output signals.

The pins (1–25) of the connector are numbered 201–225 in the diagrams.

Inputs

Pin 7: SLAVE START INSP. (0V; 5V DIGITAL CONTROL)
Pin 8: RESP. RATE = U* × 23 breaths/min/V + 5 breaths/min.
Pin 10: SIMV RATE = U* × 14.4 breaths/min/V + 4 breaths/min.
Pin 12: MINUTE VOLUME EXTERNAL
±0.05V ⟷ ±1% of set minute volume
Pin 13: PEEP LEVEL = U* × 24 cm H_2O/V-10 cm H_2O.
Pin 21: SLAVE CLOCK (0V;5V DIGITAL CONTROL)
Pin 22: PATIENT TRIG. (0V,5V DIGITAL CONTROL)
Pin 23: UPPER PRESSURE EXCEEDED (0V; 5V DIGITAL CONTROL)
Pin 25: INSP. PRESSURE (ABOVE PEEP) = U* × 40 cm H_2O/V.

U* = The on the actual pin supplied voltage. 0 volt should be connected to pin 2 or 14.

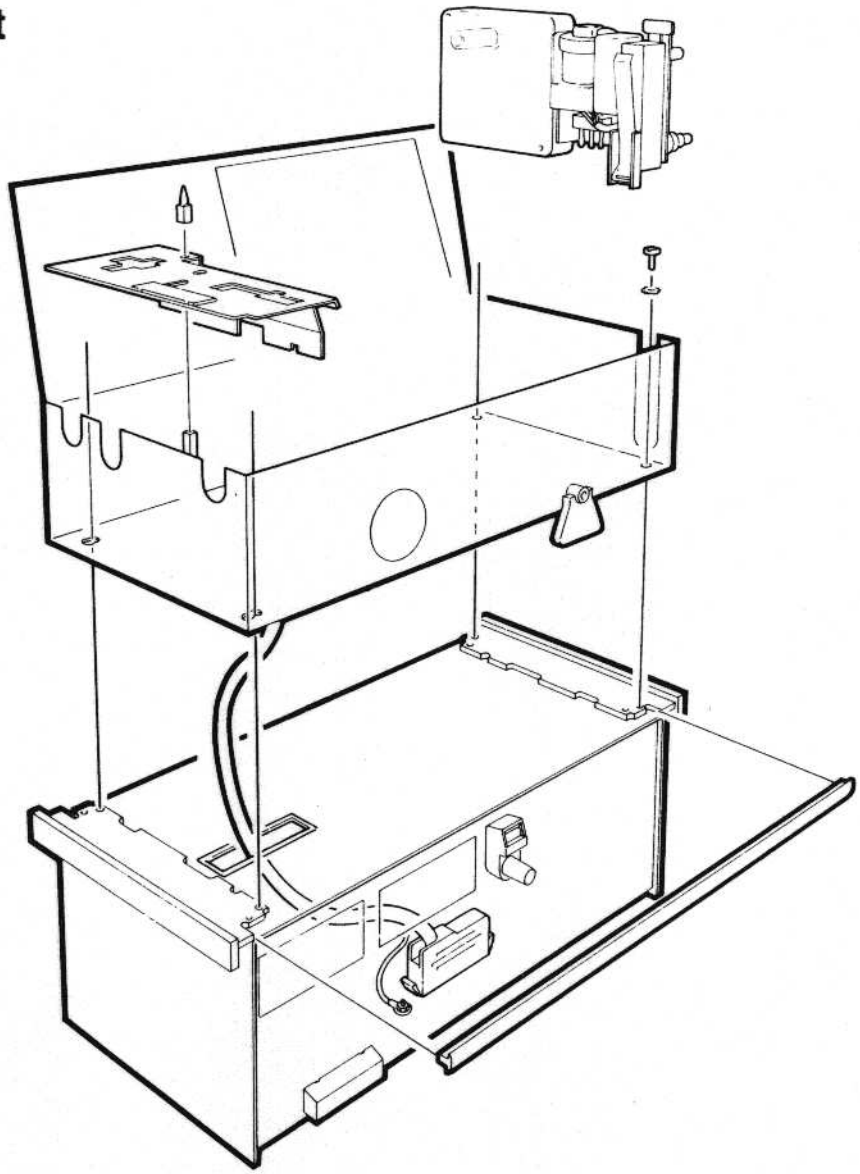
Outputs

Pin 9: MASTER START INSP. (0V; 5V output)
Pin 11: MASTER CLOCK (0V; 5V output)

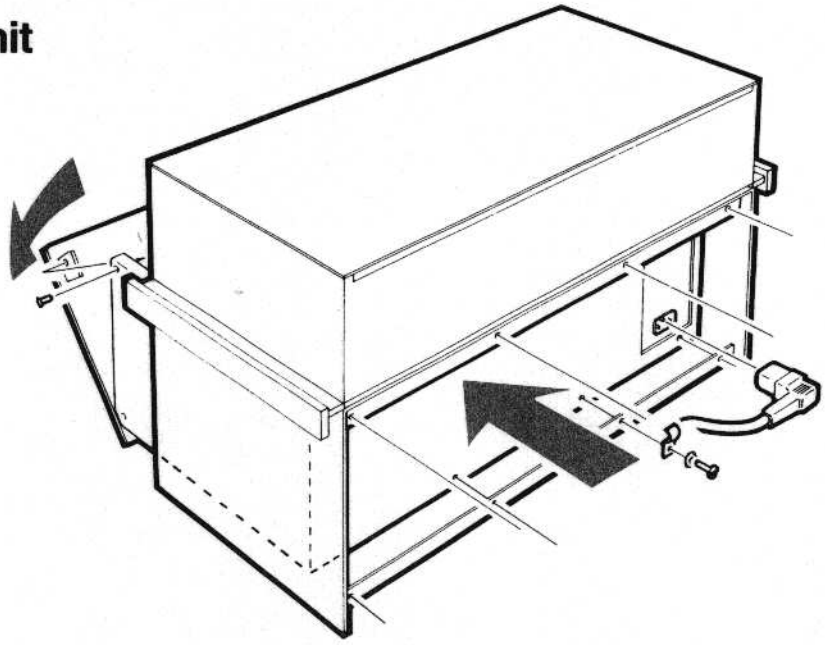
☐ = Not valid for SV 900 D

Disassembling

Pneumatic unit

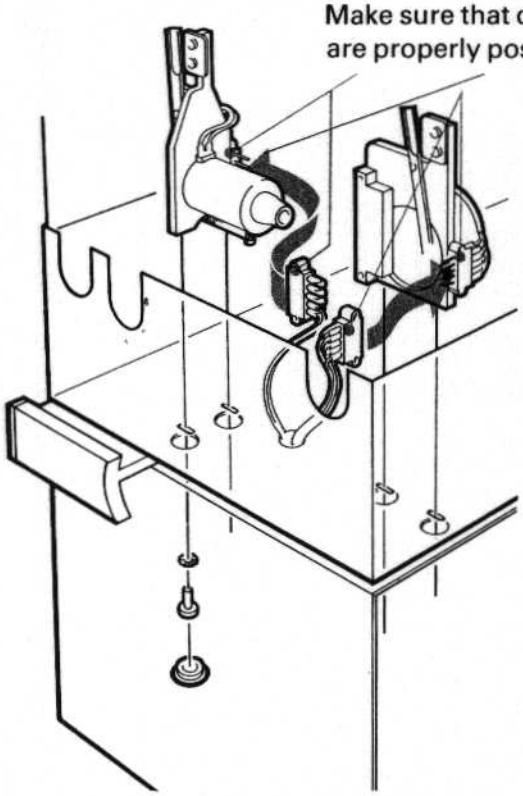


Electronic unit

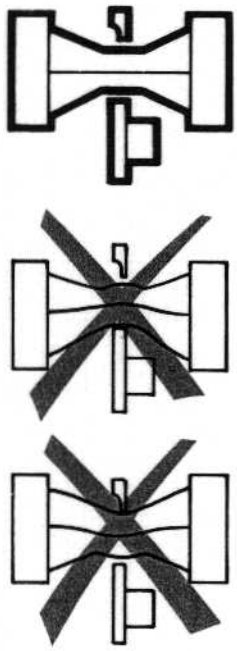


Step motor assembly and pull magnet

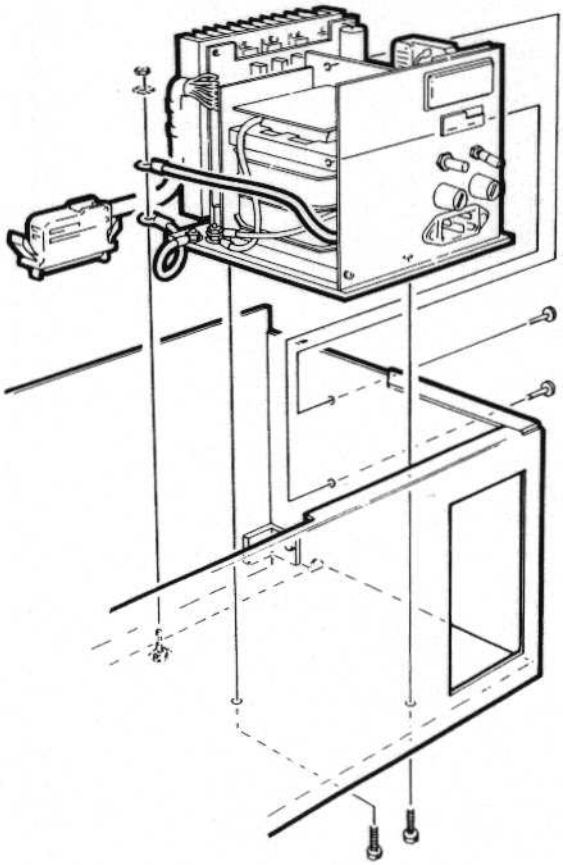
Make sure that connectors are properly positioned



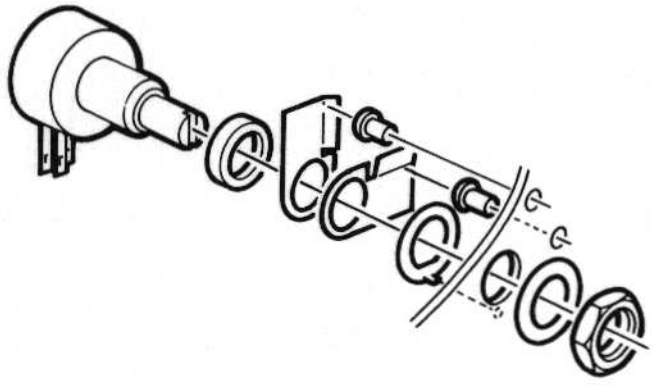
Make sure that the silicone rubber tube is not twisted



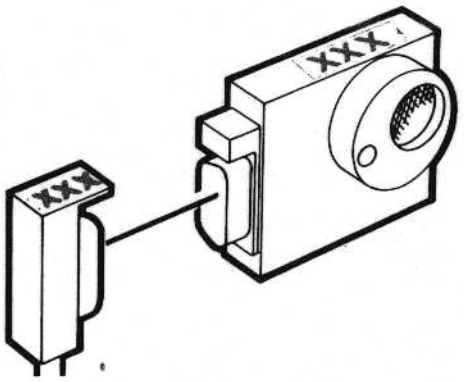
Power supply unit



Panel knob with safety catches

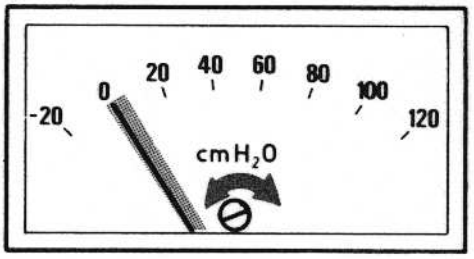


Adjustments



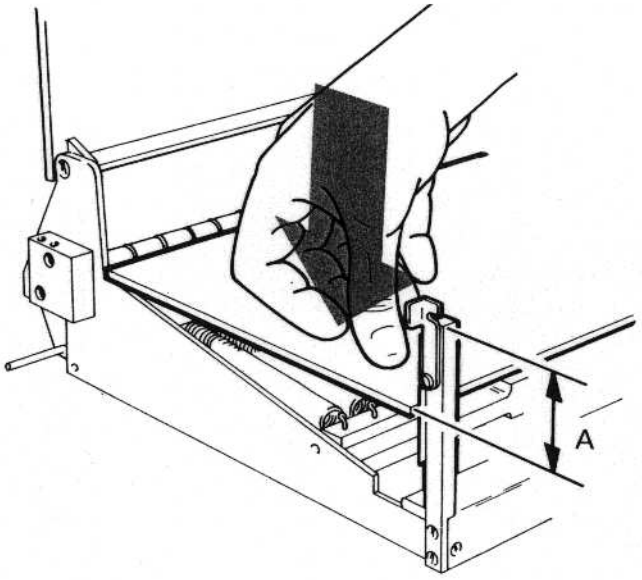
Replacement of flow transducer

The FLOW TRANSDUCER spare part includes a separate serial number label with the same number as the transducer. When replacing the FLOW TRANSDUCER, the connection plug label must be replaced with the new label.



Adjustment of meters Z1 and Z2

- Set Z1 and Z2 to zero mechanically.

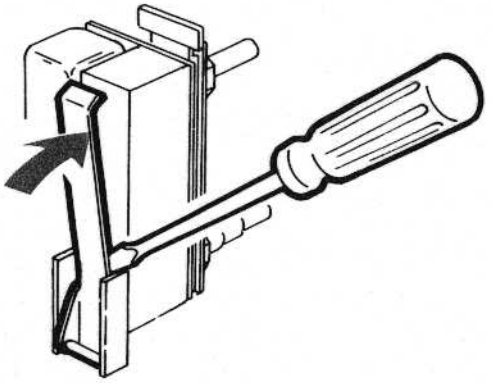


Adjustment of valve arm

Pressure plate with plastic tab

These instructions are only applicable for valve arm which is mechanically actuated by a plastic tab on the pressure plate.

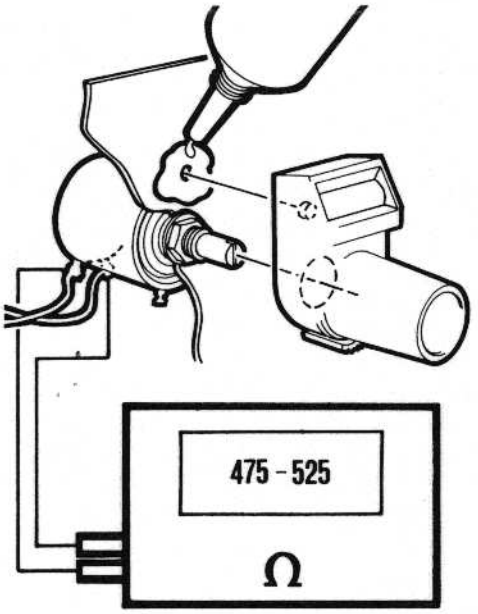
- Remove the bellows.
- Connect the device to the high pressure gas supply.
- Push down the pressure plate and release the pressure until you can clearly hear that the controlled inlet valve opens.
- With the valve in the nearly open position, the distance A must be approximately 55 mm.



- If the distance A deviates from 55 mm (i.e. the controlled inlet valve opens too soon or too late), take out the gas supply unit and carefully bend the lever arm as shown in the picture.

Pressure plate with magnet

For gas supply unit with covered valve arm activated by a magnet on the pressure plate, only the magnet on the pressure plate can be adjusted sideways. See page 11 and "Magnet kit for Servo Ventilator – Mounting instructions", Order no: 91 05 487 E313E.



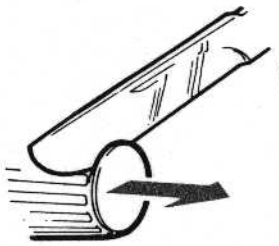
Replacement and adjustment of R5

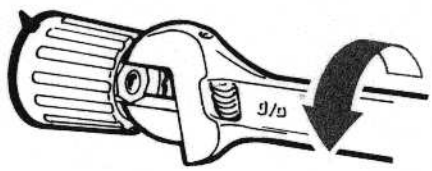
Note – This adjustment is of vital importance for faultless operation.

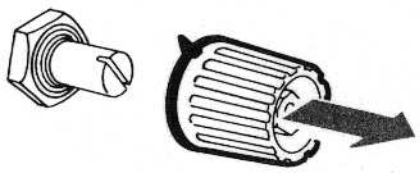
- Loosen (but do not remove) the Allen screws on the control knob. There are two screws on old knobs and one screw on new knobs.
- Protect the front panel with a soft cloth. Carefully insert a screwdriver or similar bladed tool behind the scale unit and lever it away from the front panel. Remove the complete scale unit.
- Pull out PC board no 2 (PC 756) to separate R5 from the electric circuitry of the ventilator during the adjustment.
- Connect an ohmmeter between the two pins used on R5 and turn the potentiometer shaft until the ohmmeter shows approx. 500 ohms.
- Set the scale on the scale unit to 1.0 and lock the scale in this position.
- Apply glue (Mega-Firm or similar) to the guide hole in the front panel.
- Carefully put the scale unit in position without allowing the potentiometer shaft to turn.
- Tighten the Allen screws.
- Check that the resistance between the two pins used on R5 is from 475 to 525 ohms. Otherwise, repeat the procedure described above.
- Push down PC board no 2 into correct position.
- Calibrate the ventilator according to the instructions in the chapter Calibration in the Operating Manual.

Removing the front panel knobs

- Use a knife or your fingernail to pull of the protective cap.
- Loosen the nut and pull off the knob.



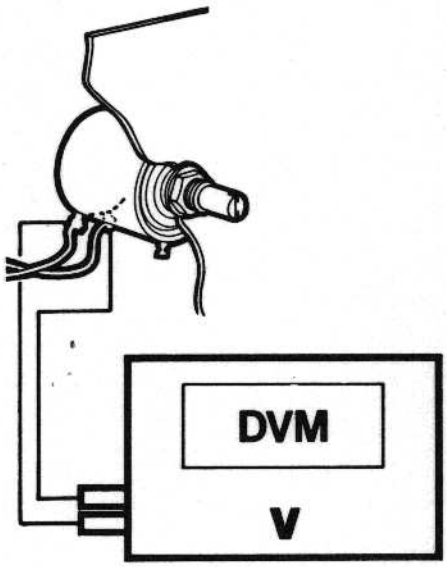




N.B. When putting the knobs back, it is important that they are mounted with the correct torque. Use a dynamometric wrench and set the following values:

- knobs with 21 mm diameter: 155 Ncm (13.7 lbf.in).
- knobs with 19.5 mm diameter (oxygen alarm): 115 Ncm (10.2 lbf.in).

Front panel potentiometer adjustments

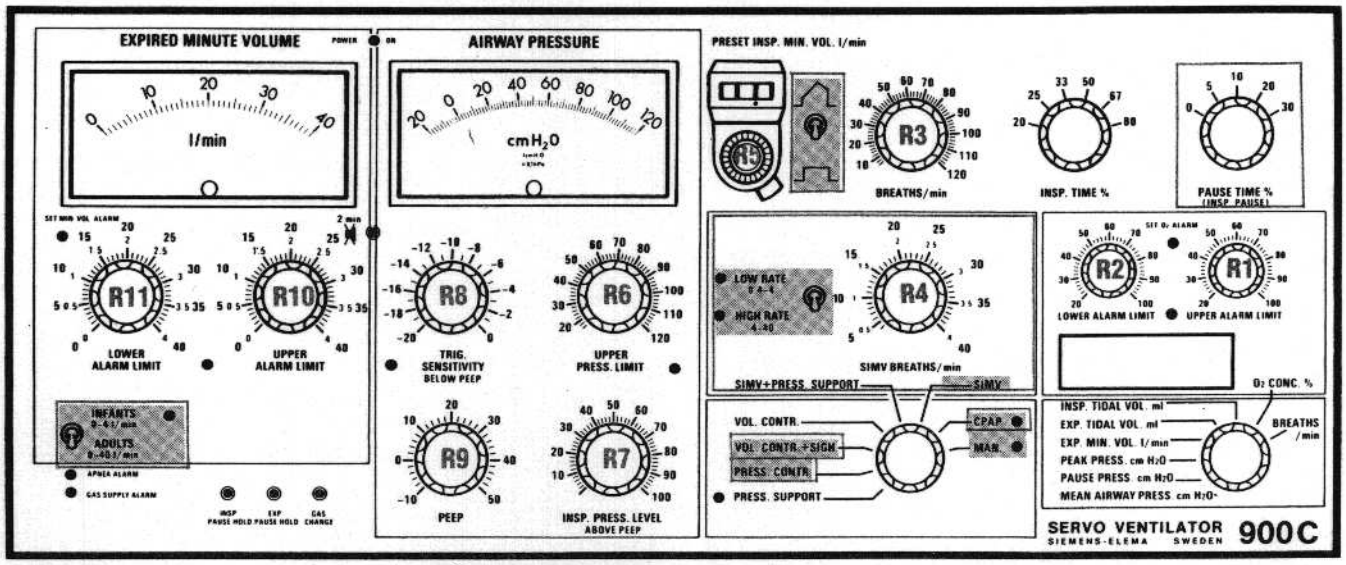


When exchanging any of the potentiometers on the front panel, use the table below for adjustments.

- Connect a digital voltmeter between 0V (REF) (black wire) and the middle point of the actual potentiometer.
- Adjust the potentiometer to the reading stated in the table.
- Carefully mount the knob at the reading stated in the table.
- Turn to the checkpoint and check the reading on the DVM.

Potentiometer number	DVM reading	Tolerance	Scale setting	Check point	DVM reading	Tolerance
R1	0.938V	0.926–0.950V	60	100	2.187V	2.162–2.212V
R2	0.313V	0.301–0.325V	20	60	1.563V	1.539–1.587V
R3	0.652V	0.627–0.677V	20	70	2.826V	2.776–2.876V
R4	1.111V	1.099–1.123V	20	35	2.153V	2.128–2.178V
R5*	500 ohm	475–525 ohm	1.0	7.5	7000 ohm	6950–7050 ohm
R6	1.057V	1.045–1.069V	60	30	0.337V	0.313–0.361V
R7	0.500V	0.488–0.512V	20	50	1.250V	1.226–1.274V
R8	0.250V	0.238–0.262V	–2	–10	1.250V	1.226–1.274V
R9	0.833V	0.821–0.845V	10	40	2.083V	2.059–2.107V
R10	1.496V	1.471–1.521V	15	30	3.370V	3.320–3.420V
R11	2.250V	2.225–2.275V	15	30	4.125V	4.075–4.175V

* For detailed description see previous page.



□ = Not valid for SV 900 D ▨ = Not valid for SV 900 E

Troubleshooting

Before you start any troubleshooting, begin, if possible, by questioning the person reporting the fault. Ask about front panel control settings, gas connections, patient connections and how the fault appeared.

Make sure that there has been no operating error. For this purpose, see also the chapter Troubleshooting in the Operating Manual.

There should be a logical trend in your tracing of the fault or faulty function. Therefore, first try to trace the faulty function, i. e. regulation of inspiration, regulation of expiration, monitoring, timing, voltage supply etc., and then the faulty part.

Always start the troubleshooting in the pneumatic unit since malfunctions very rarely occur in the electronic unit.

If you use the block diagram and the principle diagram (at the beginning of this Service Manual), the troubleshooting and servicing should not cause any difficulties.

When you have found the faulty function, the most suitable procedure is to track down the exact fault by systematically replacing individual parts, one at a time.

When systematically replacing the various parts, always start with the transducers (when used).

After exchanging transducer or any PC board, the calibration should always be checked. For details, see chapter Calibration in the Operating Manual.

When servicing a Servo Ventilator 900 C/D/E, we recommend the use of the Siemens-Elema Service Case which is available in two versions:

Service Case for SV 900 C/D/E, 50 Hz.
Order no: 90 13 236 E347E.
Service Case for SV 900 C/D/E, 60 Hz.
Order no: 90 13 244 E347 E.

Spare parts

All spare and exchange parts in the Servo Ventilator Systems are listed and pictured in the catalogue "Spare and exchange parts", Order no: 90 34 570 E323E.

Malfunction	Action
Leakage in the relief valve in spite of normal working pressure	
The controlled inlet valve opens too soon.	Check the opening positions as described in Adjustments, page 46.
The gas supply to the ventilator via the upper (low-pressure) inlet is too high.	Se Troubleshooting in the Operating Manual.
The edge of the bellows actuates the lever.	Adjust the bellows position between the pressure plates.
Uneven working pressure	
The lever arm of the relief/safety valve has slipped off its guide pins.	Put the lever arm back in position.
If the ventilator has not been used for some time the bellows may have compressed.	Extend the bellows as far as possible several times.
The gas flow to the upper (low-pressure) inlet is too low.	See Troubleshooting in the Operating Manual.
Sudden pressure drops in the gas supply system when gas mixer is used.	Check the gas supply and the mixer.
Leakage in the controlled inlet valve.	Adjust the valve or exchange the gas supply unit.
Airway pressure reading is obviously incorrect	
Leakage in ventilator.	Perform a leakage test as described in the Operating Manual.
The connections of the bacteria filter are not tight.	Tighten the connections.
The bacteria filter of a pressure transducer is clogged.	Replace the bacteria filter.
The pressure transducer is defective.	Replace the pressure transducer. When the pressure transducer has been replaced, the ventilator must be calibrated as described in the Operating Manual.
Fault in AIRWAY PRESSURE AMPLIFIER.	Replace TRANSDUCER INTERFACE (PC765) and calibrate as described in the Operating Manual.
PC board 766 and /or the wiring to the AIRWAY PRESSURE meter is defective.	Replace PC board 766 and/or repair the wiring.

Malfunction	Action
The preset inspiratory minute volume deviates considerably from the indicated expiratory minute volume.	
Leakage in ventilator.	Perform a leakage test as described in the Operating Manual.
Malfunction in regulation of inspiration.	Calibrate the ventilator as described in the Operating Manual. If the inspiratory flow transducer cannot be calibrated, the fault is in the regulation of inspiration.
Malfunction in monitoring of expiration.	Calibrate as described in the Operating Manual. If the expiratory flow transducer cannot be calibrated, the fault is in the monitoring of expiration.
The transducers and/or connections have been mixed up.	Check that the numbers on the connector and the transducer agree.
Water drops on the wire mesh net or in the measuring channel of a flow transducer.	Allow the flow transducer to dry (built-in heating element) before you start the calibration procedure. This applies to the expiratory flow transducer. The inspiratory flow transducer must be dried by other means. DO NOT USE A HAIRDRIER!
The wire mesh net is damaged or contaminated by dried deposits from disinfectants and/or patient secretions.	Replace the flow transducer or wire mesh net.
Malfunctions in the regulation of inspiration	
The inspiratory flow transducer is defective.	Replace the transducer and calibrate the ventilator as described in the Operating Manual.
The multi-turn potentiometer PRESET INSP. MIN. VOL. l/min is defective.	Replace the potentiometer.
Fault in PC board 765, PC board 759,PC board 760 or PC board 761.	Replace the board in question.
Only the accelerating flow is faulty.	Replace PC board 759.
Malfunctions in regulation of expiration	
The expiratory pressure transducer is defective.	Replace the transducer and calibrate the ventilator as described in the Operating Manual.
PC board 758 is defective.	Replace the PC board.
PC board 765 is defective.	Replace the PC board.
Flow regulated ventilation does not work properly.	Replace PC board 759.
Pressure regulated ventilation does not work properly.	Check pressure transducer (I). Replace if necessary. Check pressure transducer (E). Replace if necessary. Replace PC board 760. Replace PC board 759.
Both flow and pressure regulated ventilation out of order.	Replace PC board 760. Replace PC board 759. Replace step motor/insp. valve.

Index

N.B. This is an index of all blocks used in SV 900 C/D/E.

Function blocks in alphabetic order	Included in main block	PC board no	Page
Accelerating flow pattern	Reference level	5 (PC 759)	23
Active filter	Regulation of expiration	4 (PC 758)	40
Airway pressure (E)&(I) amplifier	Transducer interface	11(PC 765)	18
Airway press instrument selector	Monitoring	–	37
Airway pressure panel meter	Monitoring	0 (Front panel)	38
Alarm lamp flash oscillator & Alarm lamp driver	Monitoring	9 (PC 763)	36
Audible alarm	Monitoring	9 (PC 763)	36
Calculation timing	Monitoring	7 (PC 761)	38
Clock pulse generator	Timing	3 (PC 757)	30
Constant flow pattern	Reference level	5 (PC 759)	22
Direction & speed selection	Regulation of inspiration	6 (PC 760)	27
Display control	Monitoring	1 (PC 764)	38
DVM/Display	Monitoring	1 (PC 764)	38
End insp. indicator	Timing	5 (PC 759)	31
End insp. press. hold	Monitoring	7 (PC 761)	38
End pause press. hold	Monitoring	7 (PC 761)	38
End position indicator	Step motor	(PC366&PC 367)	18
End position protector	Regulation of inspiration	6 (PC 760)	27
Error signal selector	Regulation of inspiration	5 (PC 759)	26
Exp. flow linearization	Monitoring	4 (PC 758)	38
Exp. flow preamplifier	Pneumatic unit	11(PC 765)	18
Exp. minute volume monitoring	Monitoring	6 (PC 760)	35
Exp. valve	Pneumatic unit	–	18
Fast opening control	Regulation of inspiration	6 (PC 760)	27
Fast opening oscillator	Regulation of inspiration	6 (PC 760)	27
Flow averager	Monitoring	7 (PC 761)	38
Flow pattern selection	Regulation of inspiration	–	25
Flow transducer (E) & (I)	Pneumatic unit	–	18
Gas change press. ref. level	Reference level	5 (PC 759)	21
Gas supply monitoring	Monitoring	6 (PC 760)	35
High insp. pressure protection	Monitoring	5 (PC 759)	37
Insp. flow error calculator	Regulation of inspiration	5 (PC 759)	25
Insp. flow linearization	Regulation of inspiration	5 (PC 759)	25
Insp. flow preamplifier	Pneumatic unit	11(PC 765)	18
Insp. minute volume adjustment	Regulation of inspiration	5 (PC 759)	25
Insp. minute volume ref. level	Reference level	8 (PC 762)	21
Insp. press. error ampl. selection	Regulation of inspiration	5 (PC 759)	26
Insp. press. error calculator	Regulation of inspiration	5 (PC 759)	26
Insp. pressure level compensator	Regulation of inspiration	5 (PC 759)	26
Insp. press. level generation	Reference level	5 (PC 759)	21
Insp. pressure ref. level	Regulation of inspiration	5 (PC 759)	26
Insp. time & exp. time generator	Timing	3 (PC 757)	30
Insp. time & exp. time multiplexer	Timing	3 (PC 757)	30
Insp. valve	Pneumatic unit	–	18
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Integrator (I)	Monitoring	7 (PC 761)	38
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Mid. insp. time pulse	Regulation of inspiration	5 (PC 759)	26
Mode change indicator	Timing	6 (PC 760)	30
Mode control	Timing	3 (PC 757)	30
Operating time meter	Monitoring	(Power supply unit)	36
Output buffers	Input/output	8 (PC 762)	42
O_2 amplifier	Transducer interface	11(PC 765)	18
O_2 conc. monitoring	Monitoring	9 (PC 763)	35

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Function blocks in alphabetic order	Included in main block	PC board no	Page
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Peep error calculator with peep compensator	Regulation of expiration	4 (PC 758)	40
Peep level generation	Reference level	4 (PC 758)	21
Peep security valve opener	Regulation of expiration	4 (PC 758)	40
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Ref. voltage generation	Voltage supply	1 (PC 764)	41
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Ripple reduction	Monitoring	7 (PC 761)	38
Second half insp. time	Monitoring	5 (PC 759)	26
Set minute volume alarm limits	Monitoring	6 (PC 760)	35
Set O_2 alarm limits	Regulation of inspiration	9 (PC 763)	35
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SIMV timing	Timing	3 (PC 757)	30
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Step motor driver	Regulation of inspiration	6 (PC 760)	27
Timing monitoring	Monitoring	6 (PC 760)	36
Timing & supply voltage monitoring	Monitoring	9 (PC 763)	36
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Trig. level monitoring	Monitoring	4 (PC 758)	37
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Voltage controlled oscillator	Regulation of inspiration	6 (PC 760)	26
Volume compensation selector	Regulation of inspiration	5 (PC 759)	25
Volume compensator	Regulation of inspiration	5 (PC 759)	25
Working point indicator	Pneumatic unit	11(PC 765)	18
Zero setting exp. flow	Monitoring	4 (PC 758)	38
Zero setting insp. flow	Regulation of inspiration	5 (PC 759)	25
2 minute timer	Monitoring	6 (PC 760)	36
+5V regulation	Voltage supply	10(PC 754)	41
±15V regulation	Voltage supply	10(PC 754)	41
+24V regulation	Voltage supply	10(PC 754)	41

Notes

ELECTRONIC UNIT

PNEUMATIC UNIT

REFERENCE LEVEL

REGULATION OF INSPIRATION

TIMING

MONITORING

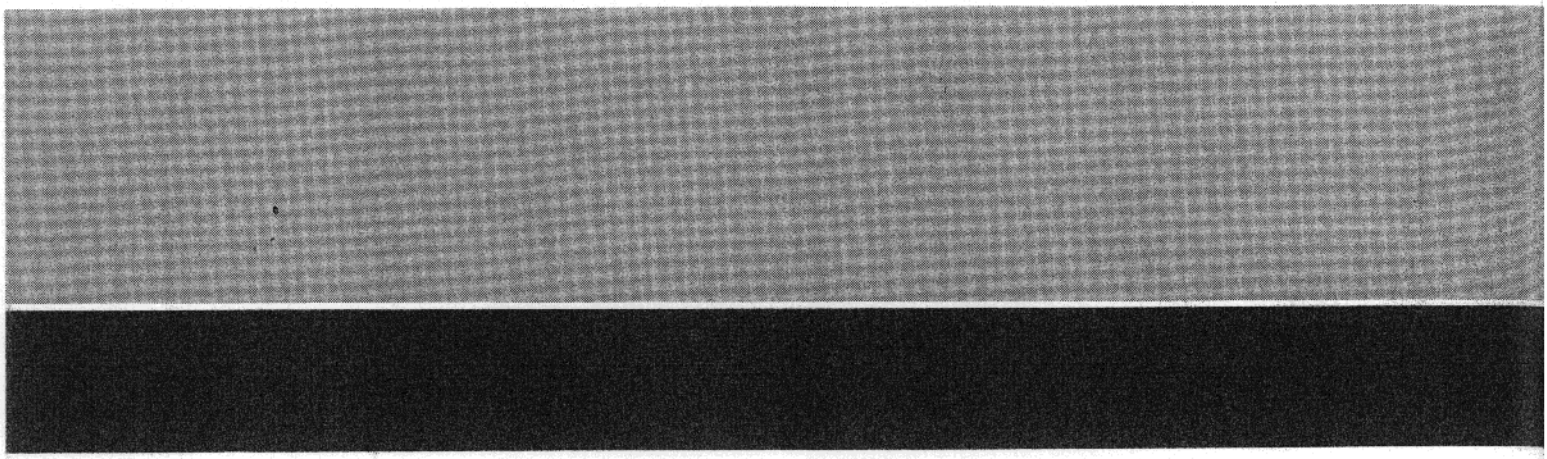
REGULATION OF EXPIRATION

VOLTAGE SUPPLY

INPUT / OUTPUT

SERIAL NO	K1-1315-01	TITLE	SV 900C/D/E KEY-DIAGRAM ELECTRONIC FUNCTION BLOCK DIAGRAM
DRAWN BY MLS	DATE 83.07.15		
APP'D BY BV	DATE 90.08.08	SCALE	COL A K / F 1 / SHEET OF
SIEMENS-ELEMA AB SWEDEN		TYPE NO E347E	ARTICLE NO 90 30 867

REV	DATE							
1	82.08.18 RO 519	3	83.04.18 RO 596	5	84.01.04 706	7	86.01.27 1352	
2	82.08.25 RO 525	4	83.04.27 RO 690	6	86.01.27 1318	8	89.01.06 2049	



Servo Ventilator 900C/D/E – Service Manual
Order No. 93 82 912 E314E

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Issued by Siemens-Elema AB, Life Support Systems Division,
Marketing Communications, S-171 95 SOLNA, Sweden.

Printed in Sweden.
S **1194** 3.
3rd English edition, November 1994

PERSSONS OFFSET